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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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Notice is Hereby Given, that

THOMAS McLEOD, of 243, Simonside Terrace, Heaton, in the City and County of Newcastle-upon-Tyne, Engineer, seeks leave to amend the Specification left in connection with the application for Letters Patent No. 107297, for "Improvements in or relating to Marine Steering Gear."

Particulars of the proposed Amendment were set forth in the *Illustrated Official Journal (Patents)*, issued on the 15th August, 1917.

Any person or persons may give notice of opposition to the Amendment by leaving Patents Form No 18, at the Patent Office, 25, Southampton Buildings, London, W.C., within one calendar month from the date of the said Journal. H 569

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as Manager or Superintendent, technical and commercial training in the various branches of engineering and shipbuilding at home and in the east. Well versed in modern repair methods and estimating, experienced in oxy-acetylene and electrical welding.—H 546, Offices of Engineering.

Secretary-Accountant Desires

POSITION. 16 years' experience motor and aeroplane trades; seven years Secretary Motor Co. Thoroughly capable and energetic. Book-keeping, balance sheets, correspondence and buying. Good organiser. Disengaged, age 39.—Address, H 547, Offices of Engineering.

THE TRAINING OF OUR INDUSTRIAL FORCES.

By H. F. L. Orcutt.

It is curious that the training and recruiting of our industrial army is so much neglected by those from whom one should expect the greatest interest and anxiety. There is plenty of brilliant talk about the trade war after the war which England proposes to wage. Are our industrial leaders as well as the rank and file aware of the fact that we are relatively in about the same condition with our industrial forces now as we were with our military forces at the beginning of hostilities? Such is the truth. We do not seem to get much further with a definite programme than a few committees, bits of tariff reform and scientific research reports.

There seems to be little indication that those who are in the best position to train an industrial army realise the danger or will rouse themselves to action. This apathy is as pronounced and dangerous as that shown by the general public, which refused to consider preparation for military defence as steadfastly as the engineering world rejects responsibility and effort necessary to our industrial safety. To convert and convince seems a difficult task, the more so as the problem in some of its important aspects is outside the area of technicalities and workshop reform. It embraces educational and social questions, the full significance of which our industrial leaders do not realise, while they largely control the means and organisation necessary to a practical solution.

Schoolmasters and Government officials can do little more than they have done and are doing in the side issues so vital to our manufacturing development unless supported and guided by our commercial and industrial leaders. A definite programme which has for its object industrial betterment must embrace general education, technical training, science and research, and economics. We must consider these subjects as interlocked and inseparable if we wish to attain to a position as leaders and put our industries in an unassailable position.

At present we hear most about that which, for the moment, is of least importance, scientific research. It is certainly necessary to our progress. A recent report,* however, demonstrates clearly enough that, under war conditions, benefits will be slow in coming and work much hindered for lack of men. As to economics, the ordinary industrial or commercial man is so little interested that it is difficult to demonstrate to him that it is of practical value that he should become informed. The principal object of the present article is to deal with that which can be at once started and which will give the greatest and largest returns. An attempt will be made to rouse the interest of the laggard manufacturer by offering him a definite "business" programme of training, and to try to show how such training is absolutely necessary to meet new trade conditions. Further, to show that if this training is not undertaken quickly and thoroughly, his "trade war" shouting will be wasted effort.

It will be necessary to digress somewhat from pure workshop problems. It will be seen that we must boldly meet the demand for higher wages, and we must co-operate with the educationalist, who has already gone so far that he will meet with open arms the industrial engineer who is in a position to assist him to make his dearest dreams become a reality.

The Post-war Condition.—Before submitting a definite programme of action it is desirable to briefly state the post-war position. There can be little controversy as to the international trade conflict which will follow the settlement of hostilities. Great Britain will have to face a competitive struggle unique in history. On the one side Germany, well equipped, highly organised, forced by defeat and debt to desperate exertions. Spurred by poverty to accept small profits, anything to regain her markets and her ruined credit. Unscrupulous and grasping methods will be backed by the German Government and financed as never before.

Germany has only to pick up the broken threads of foreign connections to supplement the home demands and thus secure the output necessary to fully occupy her large specialised mechanical equipment.

On the other side we shall find the United States, better equipped and staffed than any other industrial country, overflowing with money, with the highest credit, and a big home market, and other conditions essential to low cost production.

Great Britain's distorted industries, flanked by abnormal power and starved desperation, demand, first of all, definite and powerful Government protection. Unless this can be secured her industrial leaders will have little encouragement to undertake a programme of improvement and reform necessary to put her on equal fighting terms with America and Germany.

There is evidence that this will be insisted upon and secured. In fact this safeguard of a post-war struggle is already comparatively overweighted so much that we can almost assume that satisfactory conditions will prevail and the manufacturer of Great Britain can undertake reforms with the assurance that they will not be neutralised by foolish or neglectful legislation.

Allied and Imperial Conferences, industrial and research committees, formation of new trade and labour ministries, chamber of commerce resolutions, manufacturers' combinations, surely all are in vain unless the result is definite political action by which the position of British industry is safeguarded, having specially in view the first requisite to successful competition, that is, enlarged markets. So far the nation is roused. But the awakening must go further, and without delay. The British manufacturer, to successfully fill the demands of enlarged markets, must undertake a programme of practical reconstruction and reform involving large expenditure, organising and training his technical, commercial and manual forces. This will take several years to accomplish.

Can we expect our responsible leaders of industry to spend money and waste time without assurance that their efforts will not be wasted, they knowing the competition which must be met, competition which already has the backing of Government finance, superior equipment and trained men. The work which our political and commercial organisations must do first of all, can be, and should be, quickly accomplished. It must be fully recognised that such action must antedate the commencement of the tasks which are the subject of this article.

Industrial Strife.—If history teaches us anything it teaches us that the pursuit of individual gain, to the exclusion of all other objects and principles, results sooner or later in decay or revolution. Yet we expect our industries, in which this object practically overrides all others, to thrive. The employers cut wages, employ low-paid talent, introduce labour-saving machines, avoid "indirect" expenditure, and spend as little as possible in training men, all with the object of increasing profits. Employees restrict output, object to labour-saving machines, prevent apprentice employment, strike and intimidate, all with the object of raising their wages.

Generally speaking, throughout the whole history of English industry, from the time of the gradual breaking up of the "Guilds" to the present, there has been but little progress, except in one direction, that is, in the development of labour-saving machines. This outstanding and important feature of our twentieth-century industries has been developed under the same incentive that has produced the crop of evils which, if not eradicated, will prevent further progress. We do not need to destroy the spur to individual effort, we only need to introduce those things which make for efficiency.

First and foremost the employer must understand what the labour-saving machine means. He must understand that it saves him effort, secures cheaper production, and is the means of raising the standard of living, not the standard of one particular class, but of all classes. He must recognise that the working man knows this as well as his employers and that he intends to partake of this better standard of life and ease of effort; that the working man has a logical and scientific right to partake of the benefits of mechanical progress must also be admitted. Engineering progress is not due to any one man's effort, nor to that of any single group of men, but to the united effort of the mechanical world. The employer must further know that the working man is striking, resisting output, using every other device, both good and evil, and will continue to do so until his wages are raised to their proper level. In other words, as fast as we make further advances in industry wages must go up again and again, and keep on going up in such measure that the progress and leisure of the working man are on a level with his desires and tastes and in proportion to his effort. In short, labour must have a larger proportion of created wealth than it has had. Its share must be such that there can be no further excuse for restricting output or opposing reduction of costs. This economic necessity must be recognised or we shall not make a fully intelligent expenditure on workshop reforms and the training of men.

The question of higher wages has an important effect in another direction. It will solve at once the matter of raising the school-leaving age, as parents will be able, with an increased income, to offer no further opposition or excuse against allowing boys and girls to continue their school life at least until they are 16.

Wages must clear up this matter once and for all. It is in the power of employers, and alone in their power, to remove this barrier. It is in their own interest and that of the community to do so, otherwise the training of efficient men and women will be blocked at the start. A practical beginning will be made if employers who are ready to inaugurate new methods of training will say at once they will take no pupils unless they have reached the age of 16. Educational authorities will then be forced to follow and wages will automatically be granted to support the new condition.

We must first deal with these two absolutely necessary preliminaries to a successful system of training men, *i.e.*, raising of wages and raising the school-leaving age to 16 years as a minimum.

Old Ways and New Ways.—The training of men must be especially considered, having in view the fact that the post-war management of the majority of English engineering establishments must be on new lines.

As it always has been, is now, and ever will be, the efficient man is the most valuable asset of every business. It seems necessary to emphasise this as much as ever, particularly as we hear the idea so often expressed that with the purchase of new up-to-date machinery shop troubles are at an end. For many this has proved to be the beginning, not the end, of troubles and much disappointment, followed by shattered hopes as to increased profits.

The general engineering shop, which in England has retained its old-fashioned character longer than in any other industrial country, will be largely displaced by the specialised works. The one requires an entirely different organisation from the other. In the general shops the workmen are nearly all trained to do every sort of mechanical operation, each requiring skill. A man "sets up" his own machine, does the work, is responsible for its accuracy, keeps his own tools in order, and is not much assisted by the jig or fixture. The "general" nature of his work calls for machinery of standard types with comparatively low quantity output. He has little opportunity to become an expert in rapid production. He is usually his own inspector, does his own "planning" and "progress" work. Comparatively speaking, the machine equipment of this shop is of low capital value, consequently has low depreciation and low interest and upkeep charges. Staff and management expenses and general charges are also low.

The training of men to operate works of this nature naturally would be suitable to the production of practically one type of expert, namely, the good all-round workman. He must possess knowledge and experience of a large variety of mechanical operations. To gain this knowledge calls for a long apprenticeship, which is not necessarily accompanied by technical education. Modern productive engineering, on the other hand, is now so highly developed in detail that it is practically impossible for any one man to become proficient or expert

* Report of the Privy Council for Scientific and Industrial Research for the year 1915-16.

in all its phases. The specialised worker will outnumber the all-round mechanic and the broadly trained, highly-paid manager will replace the "works manager."

A brief analysis of the modern shop, stating the specialists required, will show that the present system of apprenticeship, such as it is, and engineering training must be superseded. The attainment of the lowest cost, combined with the right quality, is usually only possible where the responsibility of the individual worker is reduced to the simplest element. The pursuit of this principle is limited by quantities, the larger the quantity the simpler the responsibility, the smaller the quantity the more complex the responsibility.

Minute responsibility of the individual characterises the specialised factory, large responsibility the general engineering shops. In the specialised works something must take the place of disconnected responsibility. It is called organisation. Complete organisation is one which correctly determines the task of each individual and sees that he does his task. It selects mechanical outfit, lays down the operations, plans the special apparatus, selects the proper material, checks by inspection and tests, and records results. It calls for experts in every department. It is the training of these experts with which we are concerned. It is hardly possible to over-emphasise the importance of this training to our industrial army. With it Great Britain will have every element necessary to commercial supremacy. Without it that supremacy is impossible. There is undoubtedly positive danger in the present situation.

In the speeches of educationalists, reports of committees, resolutions of conferences, one searches in vain for evidence that the need of definite, strong and immediate action is appreciated. How much has been done during the last 500 years in the way of systematic training of our industrial forces that should warrant this obeseness of contentment? Both employers and employees have for centuries shirked and even directly opposed progress in this direction.

We are now faced with a struggle in trade as definite, as fierce and as widespread as that which we are now engaged in opposing with an army and navy. Is it not reasonable that we should seriously consider whether or not we are prepared to the last detail? It has been stated that we have every element necessary to success. In these is our man-power comparable with what it should be? This man-power cannot be effective without training, a training particularly arranged to meet new conditions of warfare.

Our two great competing nations, America and Germany, have already made a beginning. They have not gone so far, however, but we can overtake them. They have gone far enough to demonstrate completely the lines which must be followed, the mistakes to avoid, and the practical results which can be attained. The extreme subdivision of labour which is necessary in the modern engineering works calls for men trained to special efficiency in a particular class of work. The co-ordination necessary to the general efficiency of a thoroughly organised establishment makes it necessary that nearly every special worker must pass through a "general" experience preliminary to his special training.

Both workmen and staff may be considered under the main three divisions of:—

1. Commercial.
2. Technical or scientific.
3. Productive.

In the above items are subdivisions, varying with the nature of the business so much that, for the present, they need not be given in detail. It is contended that all members of the staff should have a minimum of three years' manual and shop experience. The classification above stated is intended to include all who, by their training and ability, are fitted to assume responsibility and directing power.

Our Managers.—It probably will not be denied that the appointments made in our industries to positions calling for responsibility, initiative, technical knowledge and directing power are largely made in a haphazard and unscientific manner. Directly the opposite is true respecting our skilled workers, who are practically all selected for whatever personal merits they may possess. The higher the position apparently the less scientific the appointment.

In place of personal merit and thorough training we find accident of birth, friendly influence, lucky speculation, "gift of gab" and money supporting inefficiency and ignorance in high places. Undoubtedly this evil condition is largely tolerated by the lack of popular understanding of the real qualifications necessary to the efficient control of our industries. The man who "makes money" and pays dividends to shareholders not only gets the highest position, but he keeps it, although he may be, and often is, very ignorant of the technical details of the business he is ruling.

In the future such a type of man is not going to have the sway that he has had in the past. The introduction of a better organisation means nothing if it does not mean that the officials of public and private companies will be carefully scrutinised with respect to their experience, knowledge and training. Clever talkers and inconsiderate sweaters of labour there always will be, probably, but our future is not assured unless they are carefully avoided, and trained men with executive character are given first consideration.

It must be conceded that "character" is the first qualification necessary to any leader. He may have all the knowledge in the world and he may not lead. In the future, however, the leader must have knowledge—knowledge highly specialised and well paid. In view of the large reorganisation of management which must take place, it will be well to specially mention some of the qualifications desirable in leading officials in engineering works before proceeding to the consideration of other definite courses of training.

Under the prevailing conditions it is quite possible, as already stated, for men to attain and hold high positions, notwithstanding that they possess but a limited technical knowledge and have very often had no practical training whatever. The industry which such men control may, for the time, seem successful, yet be marred by incompetent officials and have a rotten organisation and poor mechanical equipment. As far as a national asset is concerned it may be worse than useless, it may be a source of constant infection to the industrial community. The possibility of management of this nature thriving is all the more dangerous in view of the fact that the tendency is at present, and probably will be in the future for the formation of industrial and trade combinations, under which management is concentrated. Thus larger and larger numbers of employees and larger and larger masses of wealth will be brought under the control of inefficient individuals who block progressive management and perpetuate the use of obsolete plant.

This is the wider view which may be taken of the incompetent general manager or managing director and their danger to an industrial efficiency. From the individual company's standpoint the untrained manager is, as a rule, a hopeless stumbling-block. He neither will act himself nor let others act. He is concentrated gall to the occasional man of ability whom he may happen to retain in his services. Many an enthusiast for improvement and shop reforms will testify that the obstructive tactics of the trades unionist are a much less formidable obstacle to his efforts than the ignorant manager. The latter is a type and class more dangerous to the progress of British industry than any other. If retained, as he still is in many of our engineering companies, he will give us over to our enemies.

The training and education of the manager of an engineering concern must, in the future, be on new lines, his qualifications must be of the widest possible range, covering the experience of the routine worker and the skilled tradesman, and embracing science, commerce and economics. He must have had at least three years of manual and shop work, as a workman, not as a looker-on or student. He must work on staff duty and science, on the routine of commercial service as well as the manual. He is one of those whose calling necessitates the old-fashioned seven years' training as a minimum period.

(To be continued.)

THE COMMERCIAL PRODUCTION OF OXYGEN.

The production of oxygen on an industrial scale is one of the most interesting scientific developments of the present century, and it would be difficult to mention any product that is fulfilling a more varied and useful part in the manufacturing problems which have been occasioned by the war. The production of oxygen as a commercial undertaking dates back to 1886. In that year the present British Oxygen Company was founded as Brin's Oxygen Company, to develop a process which was claimed to be the invention of two French brothers whose name the company adopted. The Brin process for producing oxygen was based on a discovery made by the eminent French chemist Boussingault in 1851. Boussingault found that at a temperature of about 1,000 deg. F. the monoxide of the metal barium would absorb oxygen readily from the atmosphere, with the resulting formation of the dioxide, and that at a higher temperature of about 1,600 deg. F. the oxygen thus absorbed would be given off again and the barium restored to the monoxide condition ready for the cycle to be repeated. As a natural consequence of Boussingault's discovery constant efforts had been made to establish a commercial process for the production of oxygen, based on this apparently unalterable property of barium oxide. In spite, however, of its chemical simplicity many practical difficulties arose which remained unsurmounted until the advent of Brin's Oxygen Company, in 1886. Even then it was only after prolonged and costly experimental work, which resulted in most of the old methods being thrown overboard, that the barium process became an established success, gradually attaining a degree of mechanical perfection which is not often met with in chemical engineering enterprises.

Although now only of historical interest the barium process is entitled to more than passing recognition in any article dealing with the development of industrial oxygen, because the industry was not only founded, but was successfully conducted by means of that process for more than twenty years, during the whole of which time, although many other methods for producing oxygen were proposed and tried, both in this country and abroad, the barium process remained in sole possession of the field. Furthermore, it is worthy of note, in these days when it is customary in certain quarters to credit any country but our own with industrial enterprise, that in Germany, France and the United States of America the oxygen industry was started with barium plants designed and erected by the British Oxygen Company.

When the commercial liquefaction of air was achieved by Professor Linde, of Munich, in 1895, it was generally recognised that in liquefaction lay the true method of separating the constituents of air. From that date onwards there are few subjects on which the Patent Office records have been more prolific, yet it was not until many years later that the problem was solved by Linde himself, who applied the process of rectification to liquid air and thereby at last succeeded in mechanically abstracting commercially pure oxygen from the atmosphere.

Realising that the supremacy of their old process was threatened by this development, the British Oxygen Company acquired the British patents of Professor Linde in 1907, and erected in that year their first liquid air plant for the production of oxygen on the site in Westminster where twenty-one years before the first barium plant had been installed and where every subsequent development in their old process had been evolved. There, not inappropriately, a new era in the production of oxygen in this country was inaugurated, and it has led to striking developments in recent years.

To adequately describe the liquid air process of to-day within the limits of the present article would be quite impossible. Only a brief outline can be attempted. Air is now liquefied under pressure at extremely low temperatures by two methods known as internal and external expansion. In the former, which is known more especially as Linde's process, air is expanded from a high to a low pressure through a valve orifice. In the latter it is expanded partly

against the piston of an engine doing useful work and partly through a valve orifice. This is known as Claude's process. By each of these methods reduction of temperature is obtained, and by utilising the expanded air, thus cooled, to refrigerate the incoming compressed air by means of efficient heat interchangers, a self-intensive reduction of temperature takes place which ultimately cools down the incoming air to — 310 deg. F., at which temperature it becomes a liquid, the whole apparatus being cooled to a corresponding extent.

The separation of oxygen and nitrogen from this liquid air is conducted within the same apparatus by rectification, a system of distillation which originated in the alcohol industry and by means of which the more volatile components of liquid mixtures descending a rectifying column are progressively evaporated by a process of substitution which takes place with less volatile vapour ascending the column. Nitrogen being more volatile than oxygen, in other words having a lower boiling-point (— 320 deg. F. as compared with — 297 deg. F.), is thus progressively separated from descending liquid air by the condensation and substitution of rising vapours of warmer oxygen. By this process, which is termed scrubbing, nitrogen escapes from the top of the column, whilst oxygen collects as a liquid at the bottom. Both of these components are then conveyed to and discharged through separate counter-current heat interchangers, in which they progressively abstract heat from the incoming compressed air, which is thereby brought within the region of the liquefying temperature, whilst the separated gases escape from the top of the apparatus almost at atmospheric temperature. On the other hand the cold compressed air is conveyed from the bottom ends of the interchangers through a bath of liquid oxygen maintained at the bottom of the rectification column, where it is condensed to the liquid condition, and finally taken to the top of the column, from which it is released. The liquid oxygen which takes up the latent heat of this condensation is volatilised to a corresponding extent, and it is these vapours of oxygen rising up the rectifying column which effect the scrubbing process already mentioned. Thus a continuous stream of compressed air enters the apparatus at atmospheric temperature. It is there reduced to a liquid condition and its components separated. These components, then passing separately through the counter-current interchangers, are discharged back to the atmosphere (or their respective holders) at practically the same temperature as they entered the apparatus in combination.

Whilst the foregoing describes all the essential characteristics of any liquid air process, it should be explained that, although the apparatus indicated will produce pure oxygen and is still employed for that purpose, it has been found impossible by simple rectification to discharge from the apparatus nitrogen with less than a 7 per cent. oxygen content.

In modern plants, by adopting a system of compound rectification and by the introduction of other refinements, this defect has been overcome, and it is now possible to obtain practically pure oxygen and nitrogen from the same apparatus. Most of the British Oxygen Company's plants are now fitted with a simple device by which part of the waste nitrogen can be collected in a state of 99.5 per cent. purity if desired. The demand for nitrogen in cylinders is, however, as yet relatively small, being restricted mainly to the manufacture of metal-filament lamps and other purposes where an inert gas is required.

The development of the oxygen industry in recent years can, practically, be best indicated by the growth of the British Oxygen Company's business. In 1907, just before the first liquid-air plant was installed in Westminster, the British Oxygen Company had three factories in operation, these being equipped with barium oxide plants capable of an aggregate production of 30,000 cub. ft. of oxygen per day. At the present time the company has ten factories in operation in Great Britain alone, all except two being entirely equipped with liquid-air plants capable of an aggregate production of 1,000,000 cub. ft. of oxygen per day. It is anticipated that by the end of autumn this production will be increased by 25 per cent., and that two additional factories will be in operation.

It would be wrong to attribute this remarkable development to any striking economy effected by the adoption of the liquid air process, for the company's old process produced oxygen almost as cheaply. The chief merit of the present process over that using barium oxide lies in the fact that it is capable of producing oxygen of greater purity. The barium process yielded oxygen of not more than 94 per cent. quality. From liquid air the quality is never less than 98 per cent. This difference in quality is relatively unimportant so far as welding and most industrial uses of oxygen are concerned, but it almost represents the difference between success and failure in oxygen employed for metal cutting.

The metal-cutting process, which was destined to become the most important industrial outlet for oxygen, was introduced in this country by the British Oxygen Company about a year before the liquid air process for producing oxygen became available, and it was the knowledge that this important development was being retarded by the inferior quality of their own oxygen which influenced the company most in its decision to substitute liquid air for barium plants without delay. This decision has proved to be a wise one, for not only is the liquid-air process still unrivalled for the production of oxygen, but the process has itself been improved in many details, all of which, as we have indicated, have tended greatly to enhance its value.

The only other process involving the production of oxygen which has made any headway in recent years is electrolysis, by means of which oxygen and hydrogen are dissociated from an alkaline solution of distilled water. Such plants are only economical for the production of oxygen when a ready sale is obtainable at good prices for the hydrogen. Of the two factories belonging to the British Oxygen Company which are not dependent on liquid air, one is equipped with both liquid air and electrolytic plants, and the other at present obtains its oxygen supplies entirely by electrolysis. In each case the circumstances which justified the erection of electrolytic plants were exceptional, as profitable employment for the full hydrogen output was available.

Of the industrial applications of oxygen undoubtedly metal cutting, as we have already stated, comes first. The oxygen metal cutter is probably the most remarkable labour-saving tool that has ever been introduced. It is no exaggeration to state that 70 per cent. of the oxygen used in the United Kingdom at the present time is employed for cutting, and its value for this purpose in the naval dockyards, shipbuilding and repairing yards, steel works and engineering establishments is such that its use is only limited by the supply of oxygen available.

The other industrial uses of oxygen of outstanding importance at the present time are chiefly in connection with the fusion welding of metals, and more especially oxy-acetylene welding. This valuable process is employed constructionally in the welding of bombs, mines, aeroplanes and a large variety of war material. Its value for repairs of every description is demonstrated by the extensive employment of the process in the motor transport and flying services at the front. Some thousands of men and women have been trained as expert oxy-acetylene welders since the outbreak of war, and in fact there are now very few engineering works in this country which are not equipped with the oxy-acetylene blowpipe.

When it is remembered that every cubic foot of oxygen used industrially has to be distributed in cylinders, together with greatly increased supplies for military hospitals, it must be admitted that the task which lies on the British Oxygen Company at the present time is not a light one. One of the greatest difficulties the company has to contend with is the shortage of cylinders for the effective distribution of its output of oxygen. Whilst every effort has been made by the firm to obtain more cylinders, direct Government requirements have hitherto been given precedence, with the result that although the production of oxygen has steadily increased, the number of cylinders available for transporting the gas has remained almost stationary. We are glad to learn that there is at last some prospect of this disability being removed and that the company has been promised additional cylinders to cope with the present abnormal demand.

We may add, in conclusion, that those users of oxygen who may be inclined to blame the British Oxygen Company because, by its unaided efforts, it has been unable wholly to keep pace with the demand, should know that the trained staff of the company has been greatly reduced, and that at present it is conducting day and night, under difficulties which have not been adequately recognised, a rapidly increasing business involving exceptional precautions and safeguards. They should also, in justice to the company, consider what the position would have been but for the long years of private enterprise which provided the country with ten oxygen factories and a well-equipped organisation for the distribution of the gas on the very day that war was declared.

THE ARRANGEMENT OF MACHINE SHOPS.—No. XVII.

By JOSEPH HORNER.

THE closely related subjects of lifting and transport have assumed a wider significance than they did of old, in consequence of the entrance of new and more mobile systems into the shops. These have followed one another in rather rapid sequence. They are, in roughly approximate chronological order: power-driven overhead travelling cranes, swinging jib cranes, single-rail cranes, overhead tracks carrying suspended hoists, portable floor cranes. All these combine lifting with transport. The floor tracks and their trucks, and the trucks which do not require tracks, are suitable for transport only. These systems are not all eminently adapted to any and every class of service, although some have a very large range of utility. The proper spheres of these systems may be considered in the present article.

Power-driven overhead travelling cranes have no formidable rivals when heavy loads are being handled. They are usefully supplemented by swinging jib cranes and by floor tracks, but the travellers are essential for the maintenance of a quick service. No shops in which the loads to be handled are heavy now attempt to neglect their employment. Though other and newer methods of hoisting are in use, the travellers are even more necessary now than they were in the old days when hand and steam power were employed, and before electricity had been applied to their service. The increased facilities which the latter affords for rapid and economically-rated movements render these cranes absolutely essential in shops where the loads are heavy and where long distances have to be travelled. The flexibility of the travellers, their perfect adaptibility, the exact rating of power to variable services, are too well known to require amplification.

But though the traveller, by reason of its longitudinal and its cross traverse, covers every foot of shop area, and though it is capable, when fitted with an auxiliary hoist. of dealing with very heavy and with very light loads, it cannot be in several places at one time. Neither can two travellers overlap in the same area, but each must be restricted to its own sphere of action. For this reason the custom is to supplement the service of the travelling crane with that of other hoisting agents.

Swinging jib cranes are the commonest supplementary services. For although the utilities of these are limited to the area which is included by the maximum radius that they enclose, yet they can be multiplied without mutual interference with each other's action, or with that of the traveller. Usually they are located over the larger machines, and over those floor areas where a frequent crane service is required, and where, again, a crane might be held up for half an hour or more at one time. These conditions occur over the heavy machines, over erecting areas, and marking-off tables. But the jib cranes may also serve groups of light machines, still handling articles that are too heavy to be dealt with in the absence of hoisting facilities.

Frequently, even now, these jib cranes are hand-operated, but since electric power has been installed in nearly all shops, they are being driven electrically in increasing numbers, for the hoisting motion at least, the slewing and the racking being effected by hand movements in the lighter cranes.

Single-rail cranes enjoyed at one period a substantial share of favour. Running down the centre of a shop, controlled by means of a rail in the floor and one located above, and with a swinging jib, they commanded the machines on each side of the gangway. They covered a more limited area than the overhead travelling cranes serve, but sufficient for loading and unloading the machines, and including transport to and from the shop doors. They, like the travellers, were driven by hand, by cotton ropes, and later by motor. But they are being, or have already been, superseded by more efficient systems.

The foregoing are the types of cranes that have been usually installed for heavy and medium loads ranging, say, between 20 cwt. or 30 cwt. up to 40 tons, or 50 tons in the travelling cranes for the heaviest machine shops. For loads below 1 ton, or 2 tons, other services usually have preference, though overhead travelling cranes are also frequently employed for the light loads. But this is because controlling conditions vary, or that firms are not always well advised respecting the selection of machinery for hoisting and transport.

Overhead tracks, with their suspended hoists, are more useful for light and rapid service than overhead travellers are. For although they cannot cover the floor of a shop entirely, as the latter are able to do, yet they are only slightly restricted in their range of movement when branches to the inter-machine gangways are connected with the main track by curves and switches or by turntables. And in one way they are capable of much higher mobility of service, since the number of hoists can be multiplied, so that small areas can each monopolise the services of its own hoist. These are either actuated by hand, by compressed air, or by electricity. For the most part they are worked from the ground, but some of the largest are little trolleys, in which the operator is seated. These hoists and their runways, constructed after various systems, and with extensive elaborations to render them adaptable to the handling of various loads, are installed in many shops, and generally with satisfactory results. But latterly powerful rivals have appeared, and have inflicted some loss of prestige in consequence on these systems. It does not require much prophetic instinct to anticipate, not perhaps their supersession by rival services, but some abandonment of their high or exclusive claims to favour in the lighter machine shops when confronted with the rivalry of the later systems.

Portable floor cranes are a rival group, which provide another method of hoisting combined with transport. They are of light build, they run on wheels on smooth floors generally, but also on rails, and the lifting mechanism is nearly invariably hand-operated. They are deservedly popular, because they can be brought up close to the machines to unload and load, and can transport their burden to any area of the shop, or to the doors, independently of tracks usually.

All these hoisting machines, with one exception, combine hoisting with transportation. The swinging jib cranes only lift, slew and rack, covering, therefore, nothing beyond the area of floor that is included within the radius, and therefore they need the help of overhead travelling cranes, or of tracks, or of portable cranes to fetch work to them and to carry it away. And transportation must include hoisting for all loads that exceed a hundredweight or so for a single piece. But loads of a ton or more, when they comprise aggregations of lighter articles, can be handled without hoisting tackle by trucking. There is an immense volume of manufactured products which is included within this category; pieces that do not exceed a few pounds, or ounces, in weight. These light loads comprise the greater portion of even the total product of many shops, and for these the function of power-hoisting is not required, not even for the aggregate loads. These are transported on trucks direct, or on platforms, or in boxes loaded on trucks.

SHOP TRANSPORT TRUCKS.

CONSTRUCTED BY MESSRS. JOHN T. HARDAKER, LIMITED, BRADFORD.

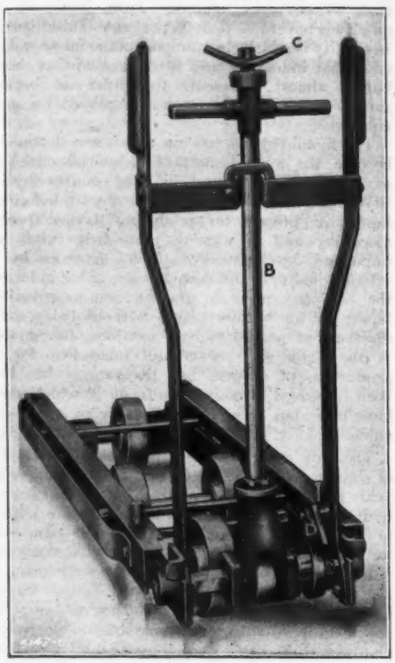


Fig. 149.

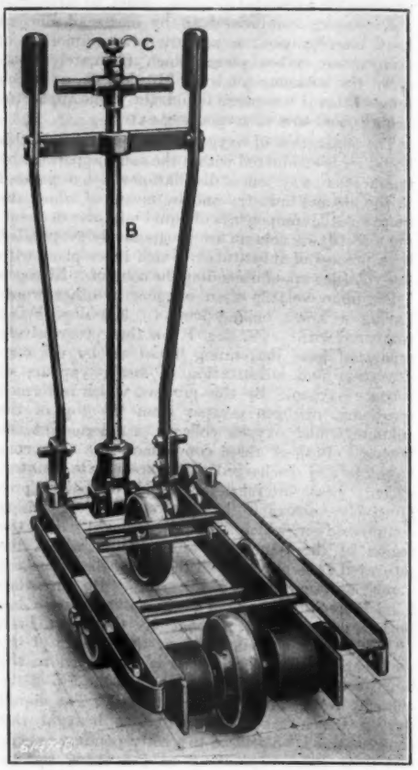


Fig. 148.

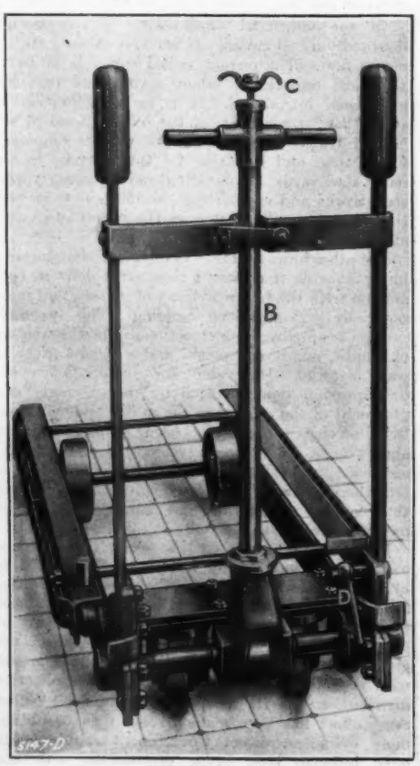


Fig. 150.

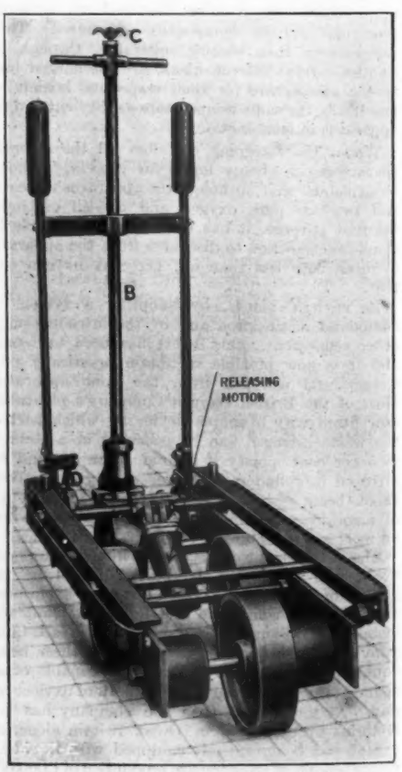


Fig. 151.

Floor tracks of narrow gauge, from 18 in. to 24 in., have been laid in many of the newer shops during recent years. These are used for the transport of loads that are put on them with overhead hoists, or which are loaded by hand. Their most suitable sphere of action is that of the shops where the lighter or the moderately heavy classes of manufacture are produced, rather than the heaviest of all. If massive work is done exclusively, the floor tracks are of little utility, and they may even block the way and interfere with the tasks of the erectors. In such shops clear floor areas are of more value for the deposit of heavy articles and for purposes of erection than the tracks can possibly be in such conditions. When heavier and lighter classes of work are being carried on under the same roof, then tracks have some value. An alternative is to lay them in those portions of the shop where they will be of undoubted utility, but to omit them in others, leaving the task of transport to devolve on the overhead-travelling cranes, or on the hoists in those areas.

But though these tracks are of much value, and though they have been regarded until recently as nearly indispensable in the shops where transportation of comparatively light loads goes on, they are not free from objections. The principal one is that they are not ubiquitous. They do not serve every machine tool. They run down the centre of the shop, with connections between adjacent shops, and sometimes with branches to certain machines. But they are not laid to serve all machines individually, or to occupy the narrow passage-ways between them, and so in this respect they fail in some degree to provide a perfect system of intercommunication. Supplementary duty is then left to an overhead crane or to hand transport to occupy the gap between the nearest rail service and the machines.

Trucks, therefore, that do not require tracks are the latest development. It is one that has made swift advances, and is already in extensive use. Several firms manufacture these trucks as a nearly exclusive product. Though these differ in respect of details, the same principle of design is apparent in them all. They are hand-elevating, transfer and transport trucks. A truck is pushed underneath a platform, previously loaded with articles in readiness for transportation. The handle or draw-bar of the truck, being lowered, causes the upper portion of the truck to lift the loaded platform off the floor, after which the truck is drawn to its destination. Conversely the raising of the handle lowers the truck away from beneath the platform, when, being drawn away, the platform is left on the floor, to be unloaded at leisure without holding up the truck idly the while. This represents an economical separation of functions in which loading and transport are differentiated.

The transport system of a shop must inevitably be associated with the problems that are concerned with the temporary storage of rough and of finished parts. The area round a machine is very frequently congested with heaps of rough and of finished pieces. These not only block freedom of movement, but two removals are entailed, one being from the truck or trolley, and the other from the ground to the trolley. When articles are of small dimensions this wasteful handling is avoided by making use of boxes to hold them—the tote boxes—which are carried on the trolleys to and from the machines. Large pieces cannot be dealt with thus, but they must be piled on the floor. Articles of medium dimensions and of shapes which cannot be piled with regularity and security may be laid on light stands, constructed suitably for their reception. But nearly anything can be deposited on platforms in readiness for the transport trucks which bring them to and take them away from the machines. The platforms have to be built for their work, being either plain-topped, which is most usual, or as boxes, or with bars to support shafts and rods, or, indeed, of any shape which happens to be the most suitable to the shapes of the articles to be loaded. The great fact in which this system differs from the others is the separation made between the functions of loading and unloading and that of transport.

These trucking systems, and also the portable stands that were described in the last article, have been in a considerable degree developed in consequence of the requirements of the shops which are dealing with munitions. Many of these are newly built, numbers—old and new—have been unprovided with either overhead rails or floor tracks. Shells and their parts are just the kind of articles for which the transport trucks with their platforms, the portable stands on wheels, and the light portable cranes are admirably suited. These appliances now are occupying the place and fulfilling the functions that were formerly largely monopolised by the rail tracks, and they possess several advantages over both. Being absolutely portable, they go anywhere into narrow passages between machines, and to all machines and benches, whether near or remote. They perform, in addition, much more than a simple trolley of the old rigid design will accomplish, since one truck will be engaged in constant transportation, instead of being held up during the whole time of loading and unloading, as the common trolley is. So that a single truck may wait upon twenty loaded platforms in quick succession, located in various parts of the building where their services may be required. The platforms may be loaded either with single large pieces, or with boxes carrying numerous small parts. Firms usually make their own platforms to suit their own products. As shown in Figs. 146 and 147, on page 192, they are of wood wide enough to embrace the width of the truck, with freedom to permit of running the latter underneath, and high enough to clear the truck when it is in its lowest position, that is previous to its elevation. When platforms are not in use they are stacked, so that they occupy little floor space by comparison with that which an equal number of trucks would require.

The illustrations Figs. 148 to 151, on page 192, show trucks constructed by Messrs. J. T. Hardaker, Limited, of the Bowling Iron Works, Bradford.

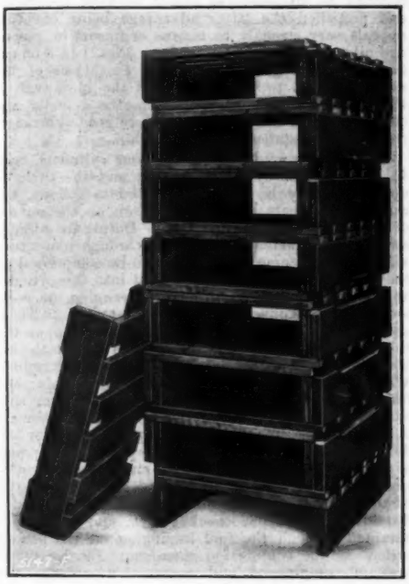


FIG 152.

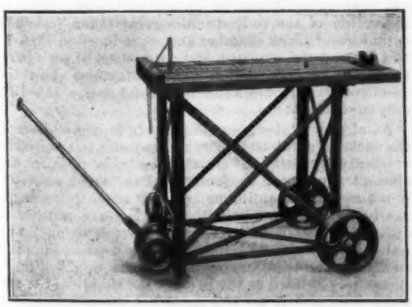
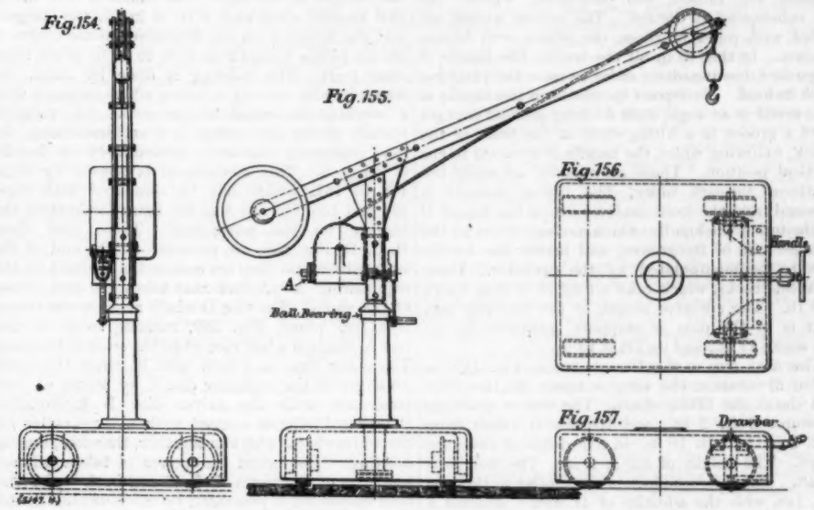
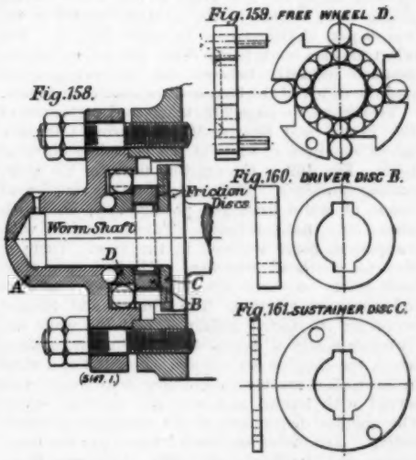


FIG. 153.

FIGS. 152 AND 153. SHOP TRANSPORT PLATFORMS; MESSRS. JOHN T. HARDAKER, LTD., BRADFORD.





FIGS. 154 TO 161. PORTABLE SHOP CRANE; MESSRS. PICKERING, LTD., STOCKTON-ON-TEES.

A truck comprises the lower frame, which carries the bearings for the wheels, an upper platform, raised and lowered by means of links which are operated by the handle, a cam and pawl for locking the load during transportation, and, in the largest sizes, a releasing mechanism for lowering the load steadily without risk of shock. The standard designs are made for dealing with loads of 3 cwt., 10 cwt. and 20 cwt. respectively. Some details of construction are varied in the different sizes.

The 3-cwt. truck, Fig. 148, has four wheels, each of the same size, two being located at the sides about the centre, and one each at front and back, a construction which enables the truck to be turned round in its own length. The peripheries of the wheels are turned, but cork-tyred wheels can be substituted if desired. The centre wheels are fitted with roller bearings, the others with bronze bushes. In this, as in all the trucks, the handle B is pushed downwards in order to raise the platform with its load. To deposit the platform the handle B is lowered to an angle until a lifting plunger engages with a groove in a lifting shaft at the front of the truck, following which the handle B is raised to the vertical position. These movements act upon the platform through links. The lifting plunger is released from the front shaft by lifting the trigger C at the top of the handle, which movement draws the plunger out of its groove, and leaves the handle free to be manipulated by the operator. These smallest trucks, which take a load of 3 cwt., weigh 100 lb. The effective length of the movable top, that is to the pins or stoppers, measures 24 in., the width 17 in., and its lift is 1¾ in.

The next size is the 10-cwt. truck, Fig. 149, in which illustration the view is taken at the front and shows the lifting shaft. The top or platform measures 3 ft. 2 in., and the width varies from 1 ft. 3 in. to 1 ft. 10 in., in five different standard types. The height of lift is 2 in. The weight is 2 cwt. The reference letters are similar to those in Fig. 148, with the addition of D, which denotes a safety catch to prevent the raised platform from falling. In a modified design, built in three types, the front wheels swivel—castor wheels (Fig. 150), which are smaller in diameter than the hinder ones. The differences in the trucks which carry the same load is in the varying heights of the top or platform when "up" or "down." The platform of the 15-cwt. truck, Fig. 151, and that of the 20-cwt. is 3 ft. 2 in. by 1 ft. 10 in. Both are also made 5 ft. 2 in. long. The difference between these and the others is that a releasing cylinder is fitted to take the weight of the load during lowering, so that it is deposited gently without shock. A stack of wooden platforms is shown by Fig. 152, page 193, which indicates their simple construction and the economy of their storage space.

Among the extensive uses to which these trucks have been put is that of the transportation of shells. Thus a stout wooden framework carries two lengths of quartering recessed to receive six shells horizontally. The truck being pushed underneath, the framing is lifted and transported bodily. There is no limit to adaptations of this kind.

Special shell-transporting trucks are made by this firm, having four wheels supporting a light framing built of angles and bars and carrying a platform to receive the shells, as seen in Fig. 153. The shells are secured between the hinged flap at the rear and the pin at the front, which is adjustable in a number of holes in a plate. A bench is fitted behind the lathe in which the shells are being turned. A pulley block with a rope and hook is fixed over the lathe to lift the shells in and out and deposit them on the bench. They are rolled from the bench to the truck, both being of the same height, and taken away. When the handle of the truck is lowered to an angle of 45 deg. the truck can be drawn along with its front legs lifted clear of the ground, and all the load is taken on the wheels. When the handle is returned to the upright position the legs come in contact with the floor.

A portable crane for machine-shop service, designed primarily for munition work, but of equal utility for general use, is shown by Figs. 154 to 157, on page 193. This is made by Messrs. Pickering, Limited, of Stockton-on-Tees, in three sizes, for loads of 2001b., 600 lb., and 7801b. respectively. The one illustrated is shown for running on rails, which are 2 ft. 9 in. gauge for the two smaller cranes and 3 ft. 3 in. for the largest size. By substituting wheels with plain treads for the flanged ones, and fitting swivelling front wheels, the same crane runs on floors of concrete or of wood blocks, with the advantage of the greater range of movement afforded when the coercion of rails is absent.

The crane is hand-operated. The post is stepped into a bogie truck, shown in detail in Figs. 156 and 157, and provided with a draw-bar. The wheels, axles and bearings are entirely enclosed, and protected by the truck. The post receives the swivelling jib, which turns on a ball race. The jib is steel-plated, and counterbalanced by the disc weight at the rear. The radius is 6 ft. in the two smaller sizes and 8 ft. 6 in. in the largest, and the height from the floor-level to the centre of the jib pulley ranges from 8 ft. to 10 ft. in the three sizes built. The hoisting is done by hand, the winch handle turning a worm which engages with a machine-cut wheel of gun-metal. A valuable feature of the lift is that it is self-sustaining, the load remaining stationary immediately the handle is released. This mechanism is shown by Figs. 158 to 161, which may be compared with Figs. 154 and 155, the cap A in the figures indicating the bearing for the worm-shaft. Three steel discs B, C, D, Fig. 158, are mounted on the end of the worm-shaft, and they are retained in position by the cap-bearing A. A ball race takes the end thrust of the shaft. The disc D which receives the thrust is a free wheel, Fig. 159, running freely in the box A, through a ball race when the crane is hoisting. The other discs also turn with it, since D is connected with the sustainer disc C by means of two pins, and with the driver disc B frictionally. C makes frictional contact with a large collar on the worm-shaft. All run together, therefore, during hoisting. But when the power is taken off the tendency of the worm-shaft to run back under the load suspended is prevented by the four balls in the recesses cut in the free wheel D, Fig. 159. During lifting these remain in the positions shown in the widest part of the recesses, in which they lie. But when the load tends to run down the rollers become jammed instantly between the narrowing recess and the inside of the box, and the load is sustained.

Two views, on page 202, taken in departments of the Brown and Sharpe Manufacturing Company afford examples of some of the preceding observations. Fig. 162 is the erecting floor for the gear-cutting machines. There are no tracks, but broad bands of white limit the passage-way, on which work may not encroach. Trucks loaded with component parts are seen in the view. There is also an overhead traveller, with two suspended hand-hoists to serve the two rows of machines in course of erection. The Brown and Sharpe shops are in storied buildings, and the walls are therefore nearly all occupied with windows, against which the benches are ranged. Fig. 163 is a view in the milling machine assembling department, also served with trucks, and with an overhead crane. The angular disposition of the machines is worth noting. The tables are much longer than the main frames and the knees are wide. Arranging them diagonally, so that one table stands in front or rear of the one adjacent, the aggregate of the floor space saved in the shop must be very considerable. These views afford striking object lessons in the advanced practice of specialised and interchangeable manufacture.

THE "BEARDMORE" MARINE OIL ENGINE.

One of the outstanding developments of recent times in marine propulsion is undoubtedly the greatly extending sphere of application of the semi-Diesel or hot-bulb type of oil engine, together with the rapid increase in power developed per unit. Quite recently this type of engine was universally regarded as being suitable for the development of only relatively small powers, say, 25 brake horse-power to 30 brake horse-power per cylinder, but recent modifications in design and the virtues of rigid simplicity have brought it greatly into favour even for powers up to 130 brake horse-power per cylinder.

The great majority of marine semi-Diesel engines have points of similarity in the system upon which they work, and practically all are of the two-stroke cycle, utilising the enclosed crank chamber for the compression of scavenging air. The "Beardmore" engine, which we illustrate on Plate XVII, has been designed essentially to meet the peculiar requirements of marine propulsion, and is the result of much experience with this type of engine installed in yachts, coasters, lighters and fishing vessels. It is particularly suited to consume fuels ranging from 0.8 to 0.9 specific gravity, but can be adjusted to use either slightly lighter or heavier oils. Working on the two-stroke cycle, it develops 160 brake horse-power while running at 280 r.p.m. This relatively slow speed of revolution is, of course, conducive to high propeller efficiency. As all bearing surfaces are liberal and materials carefully selected an outstanding feature of the engine is its capacity for long and hard service. The engine is directly reversible by means of compressed air, and requires no disconnecting clutch between the engine and propeller, the latter advantage being one that appeals very strongly to marine engineers in general and oil-engine users in particular. Figs. 1 to 3 on our two-page plate give sections and elevations of the engine, Figs. 5 to 9 are details of the main valves, Figs. 10 and 11 are diagrams from the cylinder and crank chamber, and Figs. 12 to 15 are general arrangements of an installation on board ship.

In the main engine there are four cylinders, each 11 in. diameter by 15 in. stroke, and the cycle of operations may be briefly described as follows, the reference numbers being those shown on the section of one of the cylinders in Fig. 1:—During the upward stroke of the piston air is drawn through non-return valves into the crank chamber 1, to be compressed on the downward stroke and admitted into the cylinder at the correct moment through scavenging air ports located directly opposite to the exhaust ports 2. These ports are covered and uncovered by the piston, on the top of which a deflector is arranged to give to the air blast the direction most suitable for efficient scavenging. While the under side of the piston is performing the functions of a scavenging air pump the upper side compresses the contents of the previously scavenged cylinder on the upward stroke in preparation for the downward or power stroke. A separate fuel pump is provided for each cylinder, and once in each revolution of the engine fuel is sprayed directly into the combustion chamber 3, through pulverising nozzles fitted with automatic check valves, and ignition is obtained through the fuel impinging on the heated surface of the combustion chamber. The combined heat of compression and combustion sustains the temperature necessary for ignition, and consequently no blow lamps are required except for a few minutes before starting the engine. The various operations of the working cycle can be clearly understood from an inspection of the indicator diagrams taken from the cylinder and crank chamber and reproduced in Figs. 10 and 11, and the sequence and correlation of the operations will be appreciated. These diagrams show the excellent results obtainable by careful design based on extensive experience.

As already stated, scavenging air is compressed in the enclosed crank chamber, and in order to obtain the necessary quantity of air at a suitable pressure for efficient scavenging the volume of the crank chamber is reduced to a minimum and the whole is made as nearly as possible airtight. The latter condition is difficult to attain where the shaft passes through the walls of the crank chamber, and the method adopted on this engine is interesting. A bronze ring, 4, Fig. 1, is carefully bedded to the body of the shaft close to the crank-web, and is pressed against a machined surface on the inner side of the crank chamber by springs, 5, between the ring and crank-web. The ring revolves with the shaft, and consequently wear is confined to the flat surface and automatically corrected by the springs, which exert sufficient pressure to prevent the ring leaving its face when the air pressure in the crank chamber is below that of the atmosphere. Since inefficient scavenging is necessarily accompanied by loss of power and waste of fuel, the problem of rendering the crank chamber airtight is of the utmost importance and has received much attention from engineers, but perfect airtightness has not yet been achieved. Channels are therefore provided on this engine between the main-bearing cap and the side of the crank chamber to allow the free escape of any trifling leakage past the ring, and thus to prevent the possibility of interference with the lubrication of the main-bearing bush. Air is admitted to the crank chamber through grids at the front and back covered by flexible plate valves backed by light springs, and these are mounted on large doors, 6, Fig. 3, the removal of which gives easy access to the crank-pin bushes.

It will be obvious that with this enclosed type of crank chamber, which is utilised as a scavenging pump, forced lubrication cannot be applied to the crank-pin bearings, because a large quantity of the overflow would be taken up by the air and eventually find its way into the working cylinders, with the attendant result

of excessive consumption of lubricant. The question of lubrication, therefore, is a difficult one, but has been solved in the "Beardmore" engine in a most satisfactory manner. A forced sight-feed system, with separate plunger pump and oil tube to each point where lubrication must be positive and regular, has been adopted, and by this means the quantity of lubricant supplied to any point is definitely controlled by the attendant, while any interruption of the supply due to a choked tube or faulty valve can be instantly detected and the sight glass shows clearly which point is affected. Two eight-feed lubricator boxes, 7, Figs. 1 to 3, are employed on this four-cylinder engine, and the reciprocating drive is obtained from the fuel-pump actuating gear. The 16 feeds are distributed as follow: three to each cylinder and one to each crank-pin. The cylinder feeds are disposed in such a way as to lubricate the entire working surfaces of the piston and cylinder wall, while one feed also serves to lubricate the gudgeon pin. The gudgeon pin is hollow, as shown at 8, Fig. 1, and is secured in place by a screwed pin, which is split at the point to prevent the possibility of falling out. At the other end of the hollow gudgeon pin is a plunger with a scoop end, 9, Fig. 1, which is forced against the cylinder wall by means of a spring and collects oil from the lubricating tube already mentioned. The feed for the crank-pin is carried through the side of the crank chamber and led to the interior of a revolving ring, 10, Fig. 1, from which the oil is carried by centrifugal force to its destination. The lubrication of the main bearings is effected by means of siphon tubes—an accepted marine practice.

The cylinders are cast separately and are extended below the working barrels to form the upper halves of the crank chambers. The cylinder bodies are completely encircled by ample water jackets, and large access doors, 11, Fig. 1, are provided to facilitate the removal of any deposit which may be formed therein. The cylinder covers and silencers are also jacketed, and the circulating water is supplied by a reciprocating pump, 12, Figs. 2 and 3, placed at one end of the bedplate and actuated by an eccentric, 13, Figs. 1 and 3, on the crankshaft. The pump body is of cast iron lined with brass and is provided with brass non-return suction and delivery valves, spring-loaded escape valve and a large cast-iron air vessel. Access to the suction valve is obtained by removing door 14, Fig. 3, and to the delivery valve by removing the air vessel. A bilge pump, 15, Fig. 2, of the same size and design, is placed at the other end of the bedplate and similarly operated.

The bedplate is cast in one piece, with suitable flanges for bolting down to the seating in the ship, and is provided with machined recesses to receive the main bearing bushes. The main bearing caps, 16, Fig. 1, are readily accessible for removal, and when removed the bushes, 17, Fig. 1, which are made eccentric to the shaft on their outer diameter, can easily be slipped from under the shaft without disturbing any gear whatever. The bushes are of Admiralty quality gun-metal with white metal lining.

The crankshaft is a solid forging of Siemens-Martin steel and is machined all over. Large balance-weights, 18, Fig. 1, are secured to the crank-webs, and these not only give to the engine an evenness of turning moment and a desirable freedom from vibration, but also serve to reduce the clearance volume of the crank chamber, and thus increase the scavenging efficiency.

The connecting rods are machined steel forgings fitted with adjustable bearings at top and bottom ends. The top end, 19, Fig. 1, of each rod is of special design to allow of easy adjustment, and the bearing surface is of phosphor-bronze. Examination of the gudgeon pin and bush, also piston and piston rings, is obtained by removing the cylinder cover and drawing the piston upwards after the lower end of the connecting rod has been disconnected. The marine-type crank-pin bush, 20, Fig. 1, is of Admiralty quality gun-metal, with white metal lining, and is accessible for examination or adjustment through the doors, 6, Fig. 3, arranged at the front and the back of the crank chamber.

The four fuel pumps, 21, Figs. 1 to 3, are grouped in pairs at opposite ends of the engine and are operated by the eccentrics, 13, Figs. 1 and 3, previously mentioned in connection with the water pumps, a horizontal rocking lever, 22, Fig. 3, fulcrummed at its centre, being employed to carry the fuel-pump strikers, 23, Fig. 3. The stroke of the strikers is, of course, very much in excess of that to be communicated to the fuel-pump plungers, and consequently the discharge of fuel to the combustion chambers is restricted to a very short period. The idle portion of the stroke is utilised for governing purposes, and as the action of one is identical with the others it will be sufficient to describe one. The pump striker is pivoted on the rocking lever and is free to rotate but for the action of a light spring, 24, Fig. 3, drawing it towards its guide. On the face of the guide a step is formed which throws the striker off its original course, but as this effect is counteracted by the spring already mentioned the engine speed determines whether the striker shall hit or miss the pump plunger. The tension of the spring can be adjusted to cut out at any engine speed, and when that adjustment has been made the following conditions are fulfilled:—At all engine speeds up to and including a predetermined limit the fuel pump delivers a definite quantity of fuel during a definite fraction of each engine stroke, the quantity delivered being entirely under the control of the attendant on the starting platform, and when the engine speed exceeds the predetermined limit the pump automatically ceases to operate until the normal speed is regained. When it is remembered that all four fuel pumps are alike it will be readily understood that the system of governing is very sensitive and quick in action, and it is worthy of note that the tension of the governor springs can be adjusted either individually or collectively while the engine is running. The maximum quantity of fuel to be delivered at full power is determined by a screwed collar, 25, Fig 3, on the lower end of the pump plunger. By turning this collar to right or left the plunger is raised or lowered relatively to the striker, and consequently the stroke of the plunger is limited, but this adjustment, of course, is only required when tuning the engine to suit a given quality of fuel and should not be used for any other purpose. The ordinary control of the engine speed is effected through a hand wheel, 26, Figs. 1 to 3, placed at the centre of the engine. The fuel-pump strikers are mounted on eccentrics in the rocking lever, and these eccentrics are connected by a system of levers and links to a horizontal shaft, 27, Figs. 1 to 3, running along the front of the engine. Any rotary movement of this shaft is therefore transmitted to the eccentrics, and the strikers are thus raised or lowered collectively according to the direction of movement imparted to the horizontal shaft by the hand wheel. Very fine graduations of the engine speed are obtainable in this way. A priming handle, 28, Fig. 1, is fitted to each fuel pump for charging the pipes before starting, and any pump can be put out of action instantaneously by raising the handle to a horizontal position. Should it become necessary for a pump to be put out of action permanently the screwed collar already referred to in connection with tuning meets this requirement, and when thus cut out the suction and delivery valves and springs can be removed for examination by simply disconnecting the delivery pipe and screwing out the plug in the top of the pump barrel.

Starting and reversing are effected by means of compressed air and the details of the gear, Figs. 5 to 9, show how all the operations of the engine are controlled by a single hand wheel. The hand wheel is mounted on a sleeve, 29, Fig. 9, which also carries a lever and cam No. 1 (Fig. 9), while a central spindle, 30, passing through the sleeve, carries cam No. 2 (Fig. 9). The lever is connected by a link, 31, Figs. 1, 3 and 9, to the fuel-pump controlling shaft, 27, Figs. 1 to 3, the cam No. 1 opens one of the two relief valves, 32, Fig. 8, and the cam No. 2 opens one of the two high-pressure air valves, 33, Fig. 7. The air valves are directly connected with the compressed-air reservoirs, Figs. 12 and 14, on the one side and with mechanically-operated distributing valves on the other side.

It will now be understood that when the hand wheel is turned clockwise the cam No. 2 opens the air valve on the left and admits compressed air to the ahead distributing valves, the cam No. 1 opens the relief valve on the right and places the astern distributing valves in communication with the atmosphere, while the lever brings the fuel pumps into action. The engine then starts on compressed air, but, as the fuel pumps operate immediately the engine starts, the air connection can be closed on the completion of one revolution. The latter is the function of the central spindle which carries the cam No. 2. By pushing the central spindle towards the back, the air-valve spindle drops off the cam and a spring plunger, 34, Fig. 9, entering a groove, 35, Fig. 9, in the central spindle, locks it in the new position. The hand wheel can now be used to regulate the speed of the engine without having any effect on the closed air valves, but whenever the wheel is placed in the stop position the central spindle is automatically released and is returned by a spring, 36, Fig. 9, to its original position in readiness for a fresh start in either direction. A start in the astern direction is effected by turning the hand wheel anti-clockwise, and thus placing the astern distributing valves in communication with the compressed air reservoirs and opening the ahead distributing valves to the atmosphere. Moving the hand wheel in either direction from the stop position brings the fuel pumps into action, and it is noteworthy that the driver's attention is confined to two simple operations, viz., turning the hand wheel in the proper direction and pushing the central spindle when the engine has started. The air-distributing valves, 37, Fig. 3, are actuated by the eccentrics provided for operating the water and fuel pumps, but are brought into operation only when compressed air is admitted to them, and consequently there is no wear and tear of the reversing mechanism while the engine is running. It is an admirable feature of this gear that no part of it is in motion except for a few seconds during each start or reverse of the engine, and it is therefore an easy matter to withdraw valves and other parts for examination or overhaul while the engine is at work.

Two of the engine cylinders are fitted with spring-loaded non-return valves, 38, Fig. 1, through which the air reservoirs can be charged while the engine is running. A sufficient supply can be maintained in this way for all ordinary purposes, but an independent power-driven air compressor is supplied to meet the requirements of excessive manœuvring and to renew the supply should it be lost from any cause.

Figs. 12 to 15 show a 160 brake horse-power "Beardmore" engine installed in a typical British coaster, 75 ft. long between perpendiculars, 18 ft. beam, and 8 ft. 6 in. draught. The auxiliary set consists of an air compressor and general service water pump driven by an independent oil engine, which operates on the same fuel as the main engine. The compressor is capable of charging the air reservoirs to a pressure of 350 lb. per square inch, although the main engine can be started or reversed by air at 100 lb. pressure, and this allows air to be stored in excess of the quantity required for ordinary purposes. In fact the air reservoirs are of such capacity that ordinary manœuvring requirements can be fully met by one while the other is kept charged for emergencies. The water pump is capable of performing all the duties of the main bilge and circulating pumps, and is also arranged to deal with water ballast. Fuel is stored in cylindrical tanks having a total capacity of 1,000 gallons, and this quantity gives the vessel an acting radius of 750 nautical miles. The propeller is of cast iron and has three blades of large surface, the propeller shaft is of mild steel encased in a continuous gun-metal liner, and the stern tube is of cast iron fitted with renewable lignum-vitæ bearings. The thrust block is of the most approved marine type, having individually adjustable shoes faced with white metal and a shaft-bearing at each end. The engine in this ship is 10 ft. 5 in. long from the forward face of the flywheel to the aft face of the crankshaft coupling, 5 ft. 4 in. high from centre of shaft to top of combustion chambers, and weighs 145 cwt. with silencers, flywheel, mountings and piping. The weight of the complete installation, including fuel tanks, floor plates, pipes and connections, is 14 tons, and the engine-room bulkheads are 15 ft. apart.

ENGINES FOR AEROPLANES.—In view of the urgent demand for increased aero engine or aero engine parts production, as supported by the maximum priority given to this class of work, it is of the greatest national importance that any firms who consider they are in a position to render assistance should write to the Controller of Aeronautical Supplies, Room 355, Air Board Office, Strand, W.C. 2.

GAS-DRIVEN MOTOR OMNIBUSES.—The illustrated papers have recently given views of a motor omnibus with a great gas bag on the roof containing a supply of fuel for the journey. We learn from *The Motor* that Messrs. Chapman and Sons, of Eastbourne, by running their coal-gas service from Eastbourne to London and back, have been instrumental in forming a chain of gas-charging stations on that route with improved filling facilities. At each station gas pipes have been brought out to the main road, thus obviating the necessity for running vehicles into yards and backing out. These charging stations are at the following places:—

	Miles.
Whyteleafe...	14
East Grinstead	15
Uckfield	13
Hailsham	12

INSTITUTE OF METALS.—The autumn meeting of the Institute of Metals will be held at the Rooms of the Chemical Society, Burlington House, on Wednesday, September 19, 1917. The following papers will be presented:—(1) "Experiments on the Fatigue of Brasses," by B. Parker Haigh, D.Sc. (London). (2) "Hardness and Hardening," by Professor T. Turner, M.Sc., A.R.S.M. (Birmingham). (3) "The Effects of Heat at Various Temperatures on the Rate of Softening of Cold-rolled Aluminium Sheet," by Professor H. C. H. Carpenter, M.A., Ph.D., A.R.S.M. (London), and L. Taverner, A.R.S.M. (London). (4) Note on "A Comparison Screen for Brass," by O. W. Ellis, M.Sc. (London). (5) "Further Notes on a High Temperature Thermostat," by J. L. Haughton, M.Sc. (Teddington), and D. Hanson, M.Sc. (Teddington). (6) "Principles and Methods of a New System of Gas-Firing," by A. C. Ionides (London). (7) "Fuel Economy in Brass-Melting Furnaces," by L. C. Harvey (London), with additional notes by H. J. Yates (Birmingham). (8) "The Effect of Great Hydrostatic Pressure on the Physical Properties of Metals," by Professor Zay Jeffries, B.Sc. (Cleveland, U.S.A.). (9) Note on "The Use of Chromic Acid and Hydrogen Peroxide as an Etching Agent," by S. W. Miller (Rochester, N.J., U.S.A.). Members intending to take part in the discussion of any of the above can be supplied with a copy a week before the meeting on application to the secretary, subject to the operation of the regulations restricting the use of paper.

INDUSTRIAL NOTES.

The apparent difficulties of reconstruction after the war by no means diminish on fuller consideration. No one knows what the conditions will be on the conclusion of peace, nor what burdens must be faced by ourselves and our Allies. So far as mere questions of equity are concerned there can be no question that those responsible for the war should make good to the uttermost farthing the enormous financial sacrifices suffered by ourselves and our Allies. Probably we shall have to be content with less than justice in this regard and have to face the new conditions after the war with fewer resources available for establishing new industries or extending old. If both capital and labour benefit by the lessons of the past three years the heavy burden of debt need not necessarily involve a decrease in the standard of living, but there are indications on both sides of a substantial minority who, like the Bourbons, have learnt nothing and forgotten nothing from their critical experiences.

Many employers express the view that there will be less tendency than before to grudge workmen rewards naturally due to exceptional industry or exceptional skill, and we trust it will prove so, although the present treatment of draughtsmen and foremen hardly indicates any overwhelming leaning towards liberality on the part of employers, or any increased realisation of the fact that the future of our industries will depend very largely upon a much more lavish expenditure on these so-called "non-productive" services than has been at all common here in the past. On the other hand the workmen, or at least a voluble section of them, are still clamouring for the re-establishment after the war of every rule or custom designed to restrict output. That this move shall be permanently successful is impossible in the nature of things, though it may temporarily give rise to great want and distress. The veto on the use of gas-fired furnaces for glass-melting, maintained for so many years, only delayed, to the benefit of continental competitors, the ultimate adoption here of the type, and "rights and privileges" which are indefensible either ethically or economically cannot be permanently maintained in a world in which, as most of us believe, there is, on the whole, despite many back currents, a persistent trend that makes towards righteousness.

In an interim report issued by the Reconstruction Committee the establishment of Joint Standing Industrial Councils is advocated to negotiate the settlement between employers and employed which will be necessary on the conclusion of peace. Conditions then are likely to change rapidly from month to month. At the outset there will undoubtedly be a great demand for commodities, and prices will rule high both for these and for labour. As arrears are overtaken and the demand falls off adjustments will be necessary, and the Councils are accordingly to meet at regular and frequent intervals. The object of the Councils is not so much to deal with industrial problems when they become acute as to prevent this condition arising.

Among the questions with which it is suggested that the National Councils should deal or allocate to district councils or works committees the following may be selected for special mention :—

(i) The better utilisation of the practical knowledge and experience of the workpeople.

(ii) Means for securing to the workpeople a greater share in and responsibility for the determination and observance of the conditions under which their work is carried on.

(iii) The settlement of the general principles governing the conditions of employment, including the methods of fixing, paying and readjusting wages, having regard to the need for securing to the workpeople a share in the increased prosperity of the industry.

(iv) The establishment of regular methods of negotiation for issues arising between employers and workpeople, with a view both to the prevention of differences and to their better adjustment when they appear.

(v) Means of ensuring to the workpeople the greatest possible security of earnings and employment, without undue restriction upon change of occupation or employer.

(vi) Methods of fixing and adjusting earnings, piecework prices, &c., and of dealing with the many difficulties which arise with regard to the method and amount of payment apart from the fixing of general standard rates, which is already covered by paragraph (iii).

(vii) Technical education and training.

(viii) Industrial research and the full utilisation of its results.

(ix) The provision of facilities for the full consideration and utilisation of inventions and improvements designed by workpeople, and for the adequate safeguarding of the rights of the designers of such improvements.

(x) Improvements of processes, machinery and organisation and appropriate questions relating to management and the examination of industrial experiments, with special reference to co-operation in carrying new ideas into effect and full consideration of the workpeople's point of view in relation to them.

(xi) Proposed legislation affecting the industry.

This proposal to establish Industrial Councils is endorsed by the Federation of British Industries, which has issued a commentary on the scheme insisting on the vital importance of co-operation between employers and workpeople. The Federation particularly emphasises the necessity of efficient management in every department of industry, and in this it is undoubtedly right. The kind of management which saves 100*l.* in the drawing office at the cost of 1,000*l.* increase in shop expenses has been far too common in the past. The Federation also asserts that an essential condition of securing a permanent improvement in the relations between employers and employed is that both should be adequately organised. A great difficulty in this matter is the growing reluctance of the workmen to accept the representative system of government in labour matters. The recommendations of their accredited representatives have frequently been ignored in the past, and if one may judge from certain tendencies in politics, as exemplified by the demand in American local government circles for the referendum and "recall," the distrust of the representative system is likely to increase rather than abate. The Federation holds that the proposed councils should have as a basis trade councils of masters and men, which should have the sole power of dealing with agreements of all kinds, and any other matters appropriate to the particular trade, section or industry. It is also suggested that no strike or lock-out shall be permitted to take place until the question at issue has been arbitrated on. It will, we fear, be very difficult to get the workmen to accept this condition, or to enforce it if they do accept it.

The trade returns for July, 1917, as given in *The Board of Trade Journal*, show increases in the values of the imports into the United Kingdom and of the exports of the produce and manufactures of the United Kingdom, but a decrease in the value of the exports of foreign and colonial merchandise. The following table gives the actual figures :—

July, 1915.	July, 1916.	July, 1917.	Increase (+) or Decrease (−) in 1917 as compared with	
			1916.	1915.
Imports.				
£ 75,723,767	£ 76,732,443	£ 90,182,430	(+)13,449,987	(+)14,458,663
Exports—British.				
34,721,511	46,323,057	49,833,635	(+) 3,510,578	(+)15,112,124
Exports—Foreign and Colonial.				
9,408,790	7,804,921	4,588,484	(−) 3,306,437	(−) 4,820,306

From these figures it will be seen that in July, 1917, the imports showed an increase in value of 17.5 per cent. as compared with July, 1916, and one of 19.1 per cent. over the figures for July, 1915. The value of the exports of the produce and manufactures of the United Kingdom showed an increase of 7.6 per cent., as compared with July, 1916, and one of 43.5 per cent. over the corresponding month of 1915, whilst the exports of foreign and colonial merchandise showed a decrease in value of 41.9 per cent. as compared with July, 1916, and one of 51.3 per cent. as compared with July, 1915.

The value of the trade during the seven months ended July, 1917, as compared with the corresponding period of 1916 and 1915, was as follows :—

Seven Months Ended July.			Increase (+) or Decrease (−) in 1917 as compared with	
1915.	1916.	1917.	1916.	1915.
Imports.				
£ 504,445,132	£ 550,683,207	£ 590,403,281	(+)39,720,074	(+)85,958,149
Exports—British.				
218,344,399	288,130,938	300,981,179	(+)12,850,241	(+)82,636,780
Exports—Foreign and Colonial.				
60,731,810	62,016,022	50,834,807	(−)11,181,215	(−) 9,897,003

It should be noted that in respect of July, 1917, the above figures include, so far as particulars are available at the time of compilation, articles imported and exported in public as well as in private ownership, except exports for the use of His Majesty's Forces in any theatre of war. The figures for earlier months of the present year and for all months of previous years include, in the case of imports, all articles of food, but do not include other goods which at the time of importation were the property of His Majesty's Government or the Governments of the Allies. In the case of goods exported the figures for these months include goods bought in the United Kingdom by, or on behalf of, the Governments of the Allies, but do not include goods taken from British Government stores and depots, or goods bought by His Majesty's Government and shipped on Government vessels.

On the Mersey a dispute has arisen with the Shipwrights' Society with reference to the demarcation of work. It has, however, been agreed to set up an investigation committee composed equally of employers and workmen, under a neutral chairman, to go into all matters in dispute in the whole of the firms in the port of Liverpool. In the meantime the men out will return to work pending a settlement of the points on which opinion is divided. The Birkenhead Corporation Gas Works employees are, like the boiler-makers, resenting a recent award of the Committee on Production, and in spite of the advice of the union officials, gave notice that they would cease work at 6 a.m. on Tuesday morning last.

A boiler-makers' dispute has come to a crisis on the Mersey, where the men have been out on strike for over a week. According to the chairman of the district committee of the Boiler-makers' Society there is on this occasion no quarrel with the employers, but with the Minister of Labour and the Committee on Production, who have refused to reconsider an award made by them as recently as June 23 last, holding that once an award is made, a reasonable time—say, four months—must elapse before they are called upon to examine new claims for advances. The immediate cause of the dispute can be stated briefly. In January a court of arbitration in Liverpool awarded the Mersey boiler-makers an advance of 4*s.* a week on their standard weekly wages as the result of a claim for an advance of 10*s.* made in the previous July. The men's case is that in the negotiations their claim had been made entirely on the ground that the state of trade fully warranted it, not on the ground that they should have it because of abnormal war conditions. Only the Mersey boiler-makers benefited by this award. In April a national award of 5*s.* was given by which other trades benefited, but instead of receiving this 5*s.*—as they contend they should have done—in addition to the previous award, the Mersey boiler-makers merely got the 1*s.* which placed them on a level with all the others concerned. It is this claim to an additional 4*s.* which has been refused by the Committee on Production. The present wage represents an advance of 15*s.* on previous rates, and of course the actual weekly takings have increased very much more than this figure would imply.

All sorts of explanations of industrial unrest have been preferred by different publicists. Much, no doubt, is due to irresponsible journalists, who make wild statements as to the responsibility for the increase in the cost of food. Eighteen months ago every other daily paper "expert" attributed it mainly to the increase in shipping freights, oblivious of the fact that even such an abnormal freight as 9*l.* per ton would amount to only 1*d.* per lb., which was of course a mere fraction of the total rise in price. Unfortunately few of those who discuss the subject take the trouble to go beyond vague generalities, in which all sorts of reprehensible practices are hinted at and implied, without the production of any evidence that can be definitely tested. It is difficult, for example, to understand what Mr. W. A. Appleton, secretary to the General Federation of Trade Unions, has in view in the following observations abstracted from his report : "It is hardly worth while for them to limit the rate of profit if they take no steps to limit the aggregate amount of profit. Businesses turning over 100,000*l.* before the war and making 5 per cent. since the war, and without increasing the volume of their trade and the weight of commodities they have disposed of, are, by reason of the fact that prices are double, making 5 per cent. on a turnover of 200,000*l.*, which is equivalent to 10 per cent. on the original turnover." Apparently this is based on the view that excess profit duties are not levied so long as the rate of profit on the turnover is unchanged, whereas, in point of fact, the basis is the rate of profit on the capital involved. The point is put so vaguely, however, that it is difficult to discover what Mr. Appleton really had in view. In any case the capital locked up in the merchandising of goods is greater the greater the turnover, whether the increase be due to a large volume of trade or to a rise in prices. So far as "profiteering" is concerned the workmen are not in a position to throw stones at anybody else. On occasion after occasion certain sections of them have downed tools for purely pecuniary

ends, although their action has meant death and destruction to their fellow-countrymen at the front. Occasionally this proneness to a fault which they profess so greatly to reprobate in others is confessed, as in the last quarterly report of the Associated Blacksmiths' and Ironworkers' Society, where strong exception is taken to the unfairness of smiths at Southampton in the sharing of their piecework surplus with their helpers. In commenting on the practice, which has now been stopped, the delegate very straightforwardly observes that "it would be difficult to find profiteers more rapacious amongst employers or capitalists."

An agreement was reached last week between the Railway Executive Committee and representatives of trade unions concerned on the question of increased remuneration for employees in railway companies' workshops. As regards men over 18 years the general increase in rates of wages, piece-rates, on bonus granted since the outbreak of war as the result of awards given by the Committee on Production or following negotiations with representatives of railways and the Railway Executive Committee are cancelled, and in lieu thereof the following increases apply as from August 1, 1917: To male employees of 18 years and upwards employed on time-work, 15*s.* per week war wages. Ditto, employed on piece-work, 8*s.* war wages, 7*s.* weekly on time rates, or 17½ per cent. increase of piece-work rates. The above-mentioned war wages to be taken into account in calculation of payment for overtime and Sunday work. To boys under 18 an increase of 2*s.* per week to the present war bonus total, the amount to be regarded as war wages and included in the calculation of overtime and Sunday duty, but not to rank for piece-work. An increase of bonus of 2*s.* per week to be granted to women and 1*s.* per week to girls. The increases are to be regarded as intended to assist in meeting the increased cost of living, and as due to and dependent upon the abnormal conditions prevailing through the war. The agreement remains in operation for the period of the war, and is thereafter determinable by three months' notice on either side, provided that at any time after the expiration of four months from date it is open to either side to request a revision of its terms. Nothing in the arrangement shall apply to any employees paid in accordance with the recognised district rates of wages.

In a letter to various local authorities the Canal Control Committee urges the use by manufacturers, merchants, exporters, and importers, of the inland waterways of the country for the conveyance of all kinds of traffic which can be so carried, in view of the fact that the railways are so severely taxed through depletions of staff for the Army, while they have to deal with an increased volume of traffic. The committee state that the necessity of affording them relief by such diversion is urgent. To assist it the committee has appointed three sub-committees—the Northern, Midland and Southern—with offices at Leeds, Birmingham and London respectively, which will each, with an independent chairman, be composed of representatives of canal companies and of carriers, in addition to official representatives of the War Office, Ministry of Munitions and Railway Executive Committee. These committees will exercise control over the canals in their districts. Although canal companies and carriers have lost a considerable number of their employees through war exigencies, the committee is taking steps to provide crews for as large a number of boats as possible, and hopes more boats will be shortly available. Firms are urged to make the fullest use of their wharfage accommodation, and secure wherever possible any boats that may be idle.

A miners' strike is threatened in County Durham unless a very substantial advance in wages is secured. At a council meeting of the Miners' Association it was, moreover, decided to seek to have the basis wage of surfacemen and shifters raised; to obtain a seven hours' shift for fillers after mechanical coal-cutters; to get all horse-keepers to go to the pit no more than once a day for their shift; to have rent and fire coal allowance for all married surface workers; and to make it compulsory that Government inspectors, when visiting collieries, should be accompanied by one of the local mines inspectors.

In connection with the regulation of the cotton goods output the Cotton Control Board have decided that in spinning mills where, under licence, more than 60 per cent. of the machinery is worked, the levy shall be of the uniform rate of 1¼*d.* per mule spindle for all excess spindles over 60 per cent. and 1½*d.* per ring spindle for all excess spindles above 60 per cent. A licence to work additional looms will be granted to manufacturers on the payment of a weekly levy of 2*s.* 6*d.* per loom on all looms working over and above the 60 per cent. on looms up to and including 72-in. reed space. Over 72-in. reed space the levy is 5*s.* per week per loom. A committee of the Board will also allocate a certain sum weekly to the operatives' organisation for those of their members who are temporarily unemployed. The out-of-work pay granted from the central fund will be about 25*s.* per week for men and 15*s.* per week for women. These sums will be augmented from trade union funds.

The executive committee of the Miners' Federation, who are dealing with the matter of "combing out," have passed the following resolutions: "(1) That this Executive Committee regret that on account of opposition and resentment aroused amongst the rank and file of the miners to the present scheme of recruiting, it is necessary to ask for a delay of one month in order to give time for further consideration of the matter by the miners in the various districts. (2) That we convene a special conference of this Federation to consider replies from the various districts to the following questions, which are to be submitted to the districts previous to the special conference being held: '(1) Are you in favour of the miners' organisations taking any part in recruiting for the Army? (2) Are you in favour of the present scheme as amended? (3) What modifications (if any) to the present scheme do you propose?'" Amendments to the present scheme to be sent in to the secretary not later than Saturday, August 25. Agenda will then be sent out to districts with the new scheme, and any amendments from districts will be received up to the 25th inst., in order that delegates may come fully instructed on this matter to the special conference.

Application has already been made to the Coal Controller for delay in accordance with resolution 1, and he has agreed that (*a*) certificated managers and undermanagers, under officials and deputies and (*b*) underground haulers, putters, trammers, and drawers shall be deleted from the list of exempted grades, and the names of all these men within the stipulated ages will go forward on form 22 in the ordinary way. The present new scheme is as follows: All unmarried class (A) workers at present employed in mines who were over and above the age of 18, but not over the age of 25 on January 1, 1917, except (*a*) weighmen, (*b*) winding engineers, (*c*) pumpmen, (*d*) electricians, (*e*) fitters and mechanics, including blacksmiths, joiners, wagon and tub makers and repairers.

According to the *Daily Chronicle* a scheme is under consideration for the transference of the employment exchanges from the Ministry of Labour to the National Service Department. Local machinery will be required for some of the branches of Sir A. Geddes's department, and it is thought this can be supplied by the employment exchanges, which will obviate the expense of creating new local organisations. Objection has been raised to the proposal on the ground that the administration of the exchanges, in addition to recruiting, labour substitution, and National Service would overburden the department, but having regard to all the circumstances, it is claimed that it will be advantageous to have the problem of the nation's manpower under the supervision of a single department.

A strike at the Crown Tube Works, Wednesbury, due to a dispute between a workman and the manager, has been settled owing to the public-spirited way in which the latter offered his resignation rather than by maintaining his position delay the resumption of work of national importance. The men "downed tools" without giving the Employers' Federation an opportunity of conferring on the matter with the trade unions.

The text of a Bill to make provision with respect to the searching and boring for and the getting of petroleum in the United Kingdom was issued last Saturday. It provides that the Crown shall have the exclusive right of getting petroleum within the United Kingdom, and if any person without a licence gets petroleum he shall forfeit a sum equal to three times the value of any petroleum got by him. There shall be paid into a special fund called the Petroleum Royalties Fund (*a*) in respect of petroleum got on behalf of his Majesty out of moneys provided by Parliament, and (*b*) in respect of petroleum got by a person holding a licence under this Act by the licensee, a sum equal to 9*d.* for every ton of petroleum so got. Subject to payment of expenses the sums paid into the fund shall be distributed amongst the persons interested in the land in the area in such proportions as may be prescribed; where operations for the getting of petroleum are commenced in any district, the Board of Trade shall prepare a scheme defining the area, the persons interested in the land in which are entitled to receive payments. A penalty of three months' imprisonment or a fine of 50*l.*, or both, is provided for any person, or, if a company, every director and officer of the company who refuses to give the necessary information required or gives false information. The Railway and Canal Commission are appointed to decide as to who are entitled to payments out of the royalties fund and as to how payments should be made.

A serious threat to stop all railway traffic was made during the week by the engine drivers trade union. They demanded an instant concession of an eight-hour day, failing which they declared their intention of going on strike at an instant's notice. The men admitted the impossibility under present conditions of reducing the actual working day to eight hours, but were tempted to do a little "profiteering" in the belief that they were in a more favourable position for executing a squeeze now than under normal conditions. Fortunately the matter has been prevented from coming to a head.

The President of the Board of Trade met the Executive Committee of the Associated Society of the Locomotive Engineers and Firemen at the offices of the Board of Trade on Tuesday night. The negotiations were continued until a very late hour, when an understanding was arrived at which is embodied in the following letter:—

August 21, 1917.

DEAR MR. BROMLEY,

In accordance with what I said to you last night with respect to the demand of your men for an eight-hour day, I am writing to confirm what I have stated to your Executive Committee, to your delegates when I attended a meeting on Saturday last, and also in the House of Commons, namely, that I pledged the Government, the War Cabinet and myself personally to continue the present control of the railways for a time after the cessation of hostilities, so that there would be an opportunity afforded within one month to bring forward a request for a shorter working day while the railways were under control, and that any reasonable request for a shorter working day would have the immediate and sympathetic consideration of the Government. I have also said that adequate machinery existed for dealing with any question of excessive hours or insufficient remuneration arising out of war conditions. On these two latter points I stated in my speech to the delegates that everything possible would be done by the Railway Executive Committee to reduce the long hours to the lowest possible minimum consistent with the absolute demands which are put upon the railways. I have also stated, that in so far as I am aware any demands which up to the present have been made for increased remuneration arising out of the war conditions had been amicably adjusted and I had no reason to doubt that any future demands would be dealt with in the same spirit. I will use my good offices with the Railway Executive Committee to secure that they will see the men's representatives and discuss outstanding matters at the earliest moment, this week if possible.

Yours faithfully,
(Signed) A. H. STANLEY.

The Minister of Munitions (Mr. Churchill), accompanied by Mr. Kellaway (Parliamentary Secretary to the Minister of Munitions), Major J. W. Hills, M.P., and officials of the Ministry of Munitions, the Admiralty and the Ministry of Labour, met representatives of the Engineering and Shipbuilding Trades' Federations in the Central Hall, Westminster, on Wednesday. The Minister explained to the delegates that the principal object of the meeting was to set up an Advisory Committee of Trade Unionists, the appointment of which had been discussed at previous conferences. He explained the circumstances which had led to his proceeding with the Munitions of War Bill. He stated that having gone, as he thought, a long way to meet Labour in his action with regard to the Bill, he felt he could now fairly ask Labour to help him. He appealed particularly for assistance from the trade unions in the enrolment of an increased number of War Munition Volunteers, and in seeing that dilution on munitions work was carried out to a fuller extent than at present.

He added that he would be glad to have the views of the conference on the setting up of works committees.

A full and friendly discussion followed which centred chiefly round the subject of works committees. The delegates indicated that they recognised that Mr. Churchill had met them fairly, and that they had every intention of helping him in his work.

After Mr. Churchill left the meeting the delegates discussed among themselves the construction of the Advisory Committee, and their proposals as to its membership were handed to the Minister in the course of the afternoon.

MECHANICAL TRENCH TAMPER AT COLUMBUS, OHIO, U.S.A.

The accompanying illustration shows a petrol mechanical trench-tamping device at work for the water works, Columbus, Ohio. For many years there has been a strong demand for power traction tampers for the mechanical tamping of trench backfill on streets up for improvement. It is stated that at Columbus on unimproved streets they do not tamp either by hand or machine, merely filling the trench to the top. The surface of the fill may be smoothed by hand-tamping irons, but only careful inspection will prove the effectiveness of hand operation. While the top layer may be effectively packed, there is no means of telling whether the layers were hand-tamped every 6 in. or every 12 in. There are in successful operation two power traction tampers with which any kind of soil is tamped which may be attempted by hand. In other words, the machines tamp all soils except sand, and sand would not be hand-tamped.

At Columbus 42 in. of covering are usual for any size pipe, except in instances where the cuts are not graded out and have to go deeper; 12 in. of fill are placed over the pipe line and then flushed in order that the soil may become firmly packed around the pipe at the bottom. The trench is then filled with 6-in. layers, which are mechanically tamped. The sizes of pipe to widths of trench are as follow:—

6-in. to 8-in. pipe	24-in. trench.
12-in. to 16-in. pipe	30-in. trench.
20-in. and 24-in. pipe	36-in. trench.
36-in. pipe	48-in. trench.

Each of the two traction tampers above referred to, which have been used most successfully, is operated by but one man and moves forward under its own power at a maximum speed of 1½ miles per hour. A feeding speed of approximately 6 ft. per minute is provided to furnish a continuous slow movement forward or backwards when at work on the trench. The tamping head moves across the machine on a solid steel runway. The weight of the tamping ram and its carriage is supported on 6-in. rollers. The tamping head is 9 in. by 12 in., and has a maximum cross travel of 16 in., thus enabling it actually to cover 27 in. of trench. Since it is not necessary to tamp closer than 4½ in. to the wall of the trench in most cases, the machine will handle a 36-in. trench.

The tamping head is fastened into the bar of the ram by means of heavy bolts placed through the lugs on the head. By removing these bolts the asphalt-cutting head or the concrete-breaker head may be substituted. In cutting asphalt the knife is set to run in the direction desired to cut, that is, it may be set to cut the parallel lines of the trench and then turned at right angles to cut cross-sections. The concrete-breaker head may be set without reference to direction, and is attached as described above.

The tamping ram is operated by means of a segmental pulley, brought into frictional contact with the hard-wood arm by spring pressure on a large pulley on the opposite side of the ram. This segment is caused to revolve approximately 42 times per minute, and, of course, causes a stroke of the ram at each revolution. This stroke has an average of 26 in. travel, and as the ram and tamping head together weigh 150 lb., a thorough packing of the earth results. When compared with hand labour, the machine shows its worth very forcibly.

The axles are of the stub type, and are all extended, to permit widening and narrowing of the tread from a minimum of 4 ft. 8 in. to a maximum of 6 ft. 8 in. The wheels of either side of the machine may be adjusted without regard to the other side, since it may be necessary to leave the wheels of one side close to the trench, on account of a narrow berm. This may be regulated to suit conditions, and the wheels may be placed at any point within the range of adjustment. As already stated, by substituting a cutter for the tamper head these machines may be used for cutting asphalt previous to excavating. The machine is set to travel forward at tamping speed, and cuts a clean sharp slit in the pavement which penetrates to the concrete base. After the machine has travelled the length of the trench it cuts the other side on its return trip. This strip can then be cross-cut by changing the direction of the cutter head, and the asphalt is removed in clean-cut pieces, which may afterwards be used for replacing the pavement.

The experience at Columbus, Ohio, has proved that one man operating the machine keeps two shovellers busy. These three men not only take the place of 16 hand-tampers and two shovellers at 2.25 dols. per day, but they do more and better work. The machine sets the pace for the shovellers. The tamping is thoroughly done and it is uniform. Every stroke of the 150-lb. ram is of the same length. It strikes 42 blows per minute and not more than one blow in a spot. It is true that a hand-tamper may strike many times in the spot or he may not. Hand tamps must necessarily overlap to a great extent if the work is properly done. A 6-in. to 7-in. 12-lb. hand tamp is usually dropped not more than 8 in. to 10 in. at the rate of 15 to 20 strokes per minute.

Trading with the Enemy.—An additional list of firms under enemy control with which British subjects are forbidden to trade was issued on the 17th inst. and can be obtained from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway, W.C.

AERIAL BOMBARDMENT.

In the course of an aerial fight last February Captain Guynemer brought down in the French lines one of the large German bombing aeroplanes built by the Gothaer Waggonfabrik A.G., several features of which are reviewed in *La Nature*.

In its opening remarks the French journal states that a bomb dropped from a fixed point, without initial velocity and in the absence of any wind, is submitted in its fall to two forces, acceleration due to gravity and air resistance, these forces remaining constant for all bombs of the same type; the trajectory of fall is then a vertical from point A to point B, in Fig. 1. If the bomb be dropped from a machine flying at a certain speed, the bomb at the instant it is released has an initial velocity which is equal to the speed of the machine and is in the same direction. The new force, in combination with acceleration and air resistance, gives a trajectory such as A C. If the bomb be thrown at a certain initial velocity in a layer of air in motion, it is subjected to a drift; with a rear wind the trajectory lengthens and becomes A D, and with a head wind it becomes A E. When the bomb is dropped from a machine whose travelling speed is practically equal to the velocity of the wind opposed to it, the bomb has no initial velocity and its trajectory becomes A *b*, but this case is an extremely rare one, since it supposes a wind velocity equal to the machine speed (75 miles to about 95 miles per hour) conditions in which no machines would undertake a flight.

Given these trajectories, the sighting angle will be that formed by the vertical A B at the dropping-point A with the straight line joining the dropping-point A to the point of fall O, or the angle B A O. The trajectories are curves, and the height of the machine above the target is an element which intervenes to modify them. The bombs undergo under the action of the wind a drift which varies with the shape of the bomb and the velocity of fall.

To sum up, the trajectory of a bomb dropped from a flying machine is the resultant of the following forces:—

Weight, shape and drift, which are constant elements for bombs of a given type.

Speed of the machine in the air, an element considered constant for a given type of machine.

Height of fall, initial velocity of the bomb (or speed of the machine in relation to the ground), velocity of head wind, which are variable elements.

Of these three principal variable elements which have to be known for each bombardment, one, the velocity of the head wind, is deduced as soon as the speed of the machine with reference to the ground is known, the wind velocity being the difference between

the speed of the machine with reference to the ground and its normal speed in the air. It is therefore only necessary to ascertain the height of the machine and the initial velocity of the bomb for determining a trajectory. This method of calculating trajectories endeavours to find a basis in science for obtaining results mathematically exact. But atmospheric conditions intervene, and these are most variable. For example, the wind velocity is accounted for at the height at which the machine travels, probably 12,000 ft.; but generally this velocity varies between the height of the machine and the ground-level to such an extent that notwithstanding the best calculations and the care of the most expert airmen deviations occur which lead some flying men to despair of ever attaining in an aerial bombardment results commensurate with the efforts exerted.

The Goerz sighting apparatus is certainly the most carefully finished and most improved instrument which German science has produced to attempt the destruction of objects out of the range of heavy guns. It consists of a telescope approximately 1 m. in length, mounted on a universal joint, able to take any direction and to be maintained rigorously vertical, whatever be the position of the machine. It is illustrated in Fig. 2. Fig. 3 shows the optical system; the field is 500/1,000 and the magnification 1.5. At the foot of the telescope is a prism mounted on a pivot which is actuated by a disc graduated in degrees. When the instrument is vertical the action of the prism allows the visual ray to be inclined by a number of degrees corresponding with the graduation on the disc. There are two scales on the disc, one corresponding to the vertical speed, the "dead-point" of the instrument, and the other to a sight at 22 deg. 30 minutes. Another scale on the body of the telescope acts as a basis index. At 0 deg. the ground is seen vertically (Fig. 4); at 22.5 deg. the incline of the visual ray is 22.5 deg. in front of the machine (Fig. 5); and at 5 deg. the incline is 5 deg. to the rear (Fig. 6). A small index is mobile on the disc, but it can be locked to it by means of a small knurled head. When this index is fixed in front of a graduation of the disc it falls into a notch when reaching the "dead-point," and indicates to the bomber that he sees the ground at the inclination which he had marked with the index. A spirit level is located in the instrument, and the edges of the air bubble are refracted in such a way that they appear as a dark circle, which serves as a sighting centre. The bomber has to maintain the air bubble at the centre of the eye-piece during all his sighting operations; this keeps the instrument vertical whatever be the incline of the machine. The universal joint above referred to allows the instrument to be worked freely from right to left and from front to back, but when it turns round its vertical axis, *i.e.*, when the visual ray, instead of being directed to the front or to the rear of the machine, is directed to right or left, the instrument acts upon a direction corrector. This latter is an electrical device, in which resistances act upon a highly sensitive galvanometer placed in front of the pilot, which indicates to him the rectifications he must make to fly exactly above the target.

The German arrangement allows the calculation of the three following elements. In the first place, the height of the machine above the target; this is obtained by deducting the height of the target from the height of the machine shown by the altimeter. This element, at high altitudes, can only give rise to slight errors. Thus at a speed of 90 km. (56 miles) an error in altitude of 500 m. (1,640 ft.) on a machine at a height of 4,000 m. (13,200 ft.) only corresponds to an error of 25 m. (82 ft.) on the ground (see Fig. 7).

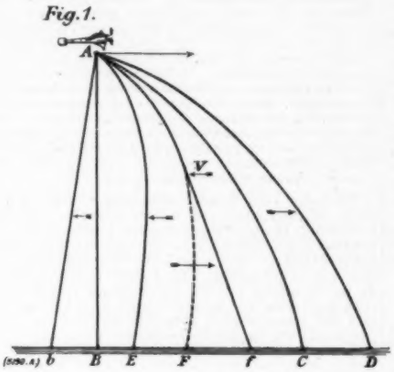


Fig. 1.

Fig. 2.

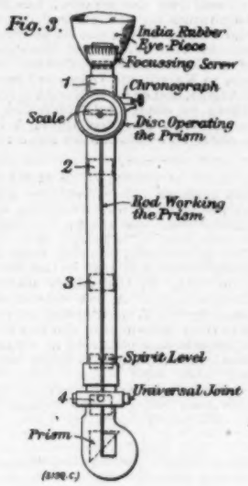


Fig. 3.

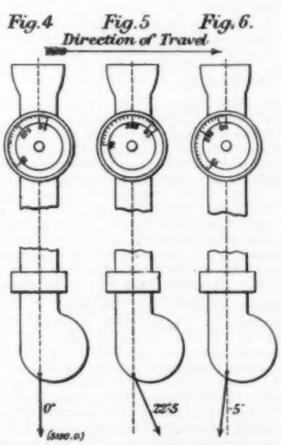


Fig. 4 Fig. 5 Fig. 6.

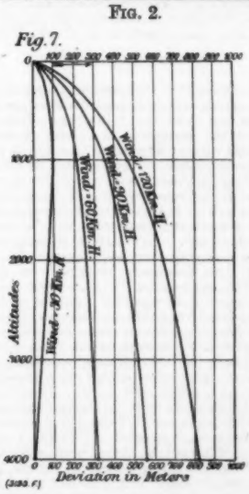


Fig. 7.

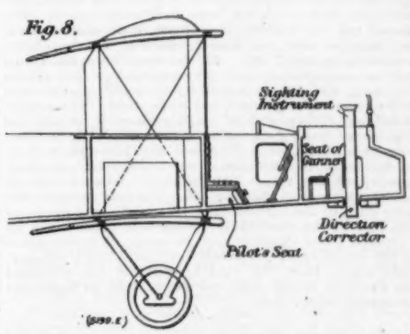


Fig. 8.

In the second place, it allows of calculating the initial velocity of the bomb. This is in reality the velocity of the bomb in relation to the ground, and is the element the most difficult to arrive at, because it varies with the speed of the wind, which itself varies constantly. If a machine develops a speed of 150 km. (93 miles) in a rear wind travelling at 50 km. (31 miles), the machine will run practically at a speed of 200 km. (124 miles), whilst with a head wind the speed would be half the latter figure. This leads to considerable modifications in the trajectories, as shown in Fig. 7. Instead of adding the speed of the wind to that of the machine, or subtracting it, the two speeds may be compounded if, for example, the wind strikes the machine in other direction than the line of flight its component must be added or subtracted in the usual way. In principle, in order to simplify the calculations, it is necessary for the machine to carry out a bombardment in a head wind, that is to say, at the least possible travelling speed. In order to determine this travelling speed of the machine one calculates the time taken by a point on the ground 0 to cover a determined angle, 45 deg. or 22 deg. 30 minutes. It will easily be seen that the time, in seconds, taken by a machine to aim successively at the same point, first at an angle of 22 deg. 30 minutes, then on the vertical, is proportional to the speed of the machine in relation to the ground. If, when the machine is at a height of 4,000 m. a point on the ground takes 36 seconds to cover an angle of 22 deg. 30 minutes, the machine will travel at 100 km. per hour with relation to the ground; if it takes only 18 seconds, the speed will be 200 km. per hour. These values form the initial horizontal velocity of the bomb.

Thirdly, the Gotha machines have a speed of 150 km. (93 miles) per hour when their engines run at their normal speed. If sighting shows that the speed with relation to the ground is only 100 km., the deduction is that the head wind has a speed of 50 m. All the elements of the trajectory are thus known, and it will suffice to read on the firing table what, under the conditions, is the suitable firing angle to insure that the bomb shall fall upon the target.

The instrument is operated by the gunner in front of the machine (Fig. 8). The releasing devices for the bombs are on his right-hand. A few minutes before arriving over the target he notes the height of the machine, which, less that of the target, gives the height of fall of the bomb, and he notes the travelling speed with reference to the ground. The index of the graduated disc is fixed at 22 deg. 30 minutes. Any point on the ground is sighted in front of the machine and is held in the circle formed by the air bubble; it is followed by turning the disc until the index falls in the "dead-point" notch; at this moment the chronograph is tripped and the point referred to continues to be followed up in the instrument until the 0 deg. of the disc stops at the "dead-point." The chronograph is then stopped and shows a number of seconds, which from the firing table gives the speed of the machine with relation to the ground and the sighting angle to use, probably 10 deg. The index is then placed on 10 deg. At about 2 miles or 3 miles before arriving over the target this latter is taken in the field of the sighting piece, then in the air-bubble circle. At this instant the direction corrector acts and the galvanometer shows the pilot that he is travelling so as to cause the machine to fly exactly above the target. At the moment when

the index falls in the "dead-point" notch, *i.e.*, when the sight is at an angle of 10 deg., the gunner releases the bomb, which falls "near the target."

During the whole time bombing lasts the pilot has to maintain the machine strictly face to the wind, the air bubble has to be maintained strictly in the centre of the eyepiece, the play of the prism alone serving to find the target. The sighting is scientifically perfect, but the result depends upon the accuracy of the observations and deductions.

Higher Railway Rates in Germany.—The Prussian Railway Department has raised the rates on the Prussian railways. The increase amounts to 2.4 pfennig for fourth class, 3.7 pfennig for third class, 5.7 pfennig for second class and 9 pfennig for first class, all per kilometre. The above increase is due to the traffic tax of 10 per cent. to 16 per cent. according to the different classes, and a rise in the basis rates of 10 per cent. on account of the increased cost of working. (1 pfennig per kilometre = about 1.5 farthing per mile.)

The Lapland Iron Ore Industry.—The large Grängesborg Company, which controls the working of the leading Lapland iron ore deposits, has found it necessary to discontinue for the present the working of the Kirunavaara iron ore deposits, on account of the difficulties connected with export and the consequent accumulation of stocks at Narvik. Further deliveries in both directions, to Narvik and Lulea, will be stopped in the middle of August, and as far as Narvik is concerned no change is likely to occur until increased storage accommodation has been provided there, a question which has been under consideration for some time.

The Latent Heat of Steam.—The latent heat of steam at standard pressure and temperature is a fundamental constant, the value of which has long been less satisfactorily known than was desirable. The values given in Kaye and Laly's "Physical and Chemical Constants" differ appreciably, ranging from the 537 calories of Regnault obtained in 1847 to the 540 calories found by Joly in 1895. In Callendar's steam tables the value 539.3 is adopted. A new determination is described in a paper by Mr. T. Carlton-Sutton, published in a recent issue of the Proceedings of the Royal Society. The plan of the experiments consisted in weighing the quantity of steam condensed upon a bulb, both when empty and when filled with water. From the two observations the latent heat can be deduced, the value found being 538.88 mean calories. It is claimed that this figure is correct to the fourth significant figure.

Swedish Shipbuilding.—The Swedish steamer companies are increasing their tonnage. Thus the Transatlantic Company has just ordered four additional boats from the Lindholmen yard, two of 8,000 tons deadweight each and two of 3,500 tons deadweight each. The former will be 378 ft. long, built with shelter deck, five hatches and ten steam winches, electric light, wireless telegraphy, &c. In the deck-house amidships will be mess-rooms and accommodation for officers and men, the captain's deck-house being on the boat deck; the crew's quarters will be forward. The engine, placed amidships, will be triple-expansion, giving the ship, when carrying an 8,000-ton load, including bunkers, a speed of 10½ knots. The two smaller boats will be 265 ft. long, with four hatches and six winches; carrying capacity, 3,500 tons. The officers' quarters will be amidships, those of the crew aft. The four steamers are being built to the highest class at Lloyd's, and are to be delivered in the year 1921. These four boats make up a total of seven steamers now in course of construction for the company and its subsidiary, the Viking Company. Since April, 1916, the yard in question has delivered five steamers to the same company, with an aggregate tonnage of 16,000 tons.

New Use for Sulphite Residue.—A rational and remunerative exploitation of the residual lye from sulphite manufacture has for some considerable time been the subject of exhaustive experimenting on the part of several Swedish experts, and from what has now been made known, novel and satisfactory results have been achieved which are likely to prove of great practical value. It has been calculated that for Sweden alone the waste of organic substances through the methods hitherto followed amounts to as much as 800,000 tons per annum, and so far only 16 per cent. of the lye has been made useful in the manufacture of alcohol. During the war, however, sulphite lye has been in much demand as a substitute for coal tar, for a cementing substance in lieu of resin and glue, and as a raw material in the manufacture of dyestuffs, of which there has been great scarcity in Sweden, as elsewhere, during the war. The difficulty so far has been found in the concentration of the lye, which contains 90 per cent. of water; this difficulty, however, is now said to have been entirely overcome. The new method consists in removing the water by means of freezing, whereby four-fifths of the water is disposed of. With the present high prices for fuel the new method of manufacturing spirit means a material saving, compared with those hitherto employed, the cost, it is reckoned, being reduced by some 40 per cent. In the new method, which bears the name of Oman, the water power of the country will be employed in the freezing process, and the organic substances of the lye will be separated in such a form that they can be used in a variety of industries, and an experimental factory to solve these problems is about to be started.

COLONIAL ENGINEERING PROJECTS.

We give below a few particulars, taken from *The Board of Trade Journal*, concerning several colonial engineering projects. Further information concerning these can be obtained from the Department of Commercial Intelligence, 73, Basinghall-street, E.C. 2.

South Africa.—The Imperial Trade Correspondent at Johannesburg has forwarded a copy of the specification, tender form and blue prints in connection with a call for tenders by the Johannesburg Municipal Council, as follows: Sealed tenders, on the proper forms, will be received by the Town Clerk, Municipal Offices, Johannesburg, up to noon on September 20, for the supply and delivery of spare parts for Blake-Marsden, 20-in. by 10-in. eccentric-motion stone breakers. (Contract No. 290.) Copies of the specification, conditions of contract, and forms of tender, together with blue prints, may be obtained from the Controller of Stores, Johannesburg. It will be observed that the time for the receipt of tenders is limited, and, owing to forms having to be obtained from South Africa, this intimation will be of use only to firms having agents in the Union who can be instructed by cable.

The Channel Tunnel.—In the House of Commons last week Mr. Bonar Law announced that, having taken the opinion of their naval and military advisers, the Government did not consider it practicable to proceed further with the construction of the Channel Tunnel until the end of the war, and could not for the present support any private Bill authorising the work to go on.

The Metric System in America.—According to the *American Machinist* aeroplane makers in the United States decided some little time back to use metric measurements in conformity with British and French practice. On reconsideration, however, it has been decided that the step would cause delay in the production of the large output contemplated, and the English system will accordingly be used for everything but such items as spark-plug threads. Even the ball bearings are to be based on the English inch, although the metric system has been largely used for these in the past.

Autoclave.—A simple autoclave, convenient for experimenting with aqueous solutions at temperatures up to 300 deg. C., is described by Professor G. W. Morey in the Journal of the Washington Academy of Science, April 19, 1917. The autoclave consists of a bomb, a cylindrical cup, fitted into a cylindrical shell. Both parts are made of standard gas-piping, the bomb of 3½ in., the shell of 4-in. piping. The upper rim of the bomb wall is cut in step fashion; into these steps fits the heavy cover of the bomb which, with its outer rim, bears against a shoulder on the shell when the bomb is raised by means of a screw pressing against its bottom; a gold wire, 0.8 mm. in diameter, is placed in the step and seals the bomb hermetically when the screw is tightened.

Japanese Shipping and Shipbuilding.—An interesting article on this subject appears in the *Japan Advertiser*, from which we take the following: Before the year 1917 is over the shipyards of Japan expect to launch 97 steamships with an aggregate tonnage of 400,000 tons. Thirty-one merchantmen, aggregating 108,755 tons, and each exceeding 500 tons, were completed at various shipbuilding yards in Japan during the six months ended June 30 this year. Sixty-six more, representing 297,644 tons, each of more than 500 tons, will be finished before the end of this year. As for 1918, 20 cargo vessels, each of 9,000 tons, aggregating 180,000, will be built in one yard alone—the Kawasaki Dockyard at Kobe. They will be worth approximately 72,000,000 yen. Most of these 20 vessels, it is expected, will be sold to Britain. Notwithstanding frequent speeches by Baron K. Den, Minister of Communications, expressing his strong desire that his countrymen should refrain from selling ships to foreign buyers, the Government appears not inclined to interfere in connection with such a tremendous shipbuilding project announced by the Kobe firm with the intention of selling its ships to foreign nations so long as they go to Britain or some of the Allied nations. Thirty-two merchantmen, aggregating 133,761 tons gross and 200,000 tons deadweight, have been sold by Japan to England, France, Italy, America, Spain and Norway since the war. They are valued approximately at 85,000,000 yen. Besides, Japan has sold 90 trawlers to foreign countries. They are estimated at 15,000,000 yen in value. Therefore Japan has obtained 100,000,000 yen from foreign nations since the outbreak of the war by selling her ships and trawlers. In addition to ships sold and building, Japanese owners have chartered to foreign countries—almost entirely allied countries, the exceptions being neutrals—55 Japanese merchantmen, aggregating 178,104 tons gross and 231,535 tons deadweight. These vessels are under charter of the firms and Governments of Italy, France and England. They are sailing on the Indian and Atlantic Oceans and in the Mediterranean Sea. Some Japanese boats are also under charter of American firms, and are plying on the Pacific. It is generally believed that Japan will obtain charter fees approximately amounting to 60,000,000 yen this year. Japan received more than 60,000,000 yen from various foreign nations as charter rates last year. Steps are already being taken by the organised shipping industry to conserve the future of Japan shipping and to safeguard Oriental interests in the matter of American competition.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scotch Steel Trade.—Even with the added output of steel of every grade which has recently been made possible the entire production is as rapidly absorbed as turned out. What the actual output is will never be known until after the war is over and then the revelation will be something more than "a nine days' wonder." The constant and growing activity in the shipbuilding yards has greatly increased the necessity for steel considerably in excess of anything hitherto known in the trade, the programme instituted by the Shipping Controller being prosecuted with the most persistent energy. There is no diminution, therefore, in the demand for the ship plates, angles and sections required. More and more does the ordinary customer, both at home and abroad, find himself and his needs a matter of very minor importance, Government, as is naturally to be expected, coming first all the time, and his requirements are fitted in entirely at the convenience of the makers.

Sulphate of Ammonia.—Much attention has recently been given to the available supplies of sulphate of ammonia and to the price at which it is now procurable by agriculturists, who undoubtedly owe a debt of gratitude to Government for having fixed the price at from 15*l.* to 16*l.* per ton. One of the speakers at the Agricultural Conference in Edinburgh, Mr. Charles Fraser, of Melrose, a gentleman who has had a long connection with the Scottish oil industry, drew attention to the fact that in the coal production of Britain there existed a source of fertiliser which was admittedly the finest fertiliser known. In Midlothian alone the ordinary yield of sulphate of ammonia from shale amounted to 2 per cent., while that from coal reached the higher figure of 3 per cent. to 4 per cent. Looking forward, Mr. Fraser estimated that in the future all the coal burned in Britain would, primarily, be treated at the pit head. Thirty million tons of coal would give a yield of 600,000 tons of sulphate of ammonia.

Malleable Iron Trade.—Although conditions in the malleable iron trade continue as active as ever, a very remarkable change has taken place within recent months, gradually and insidiously. In pre-war days Scottish-made "Crown" bars were known throughout the world and valued accordingly by buyers in every direction. It is, therefore, all the more disappointing to these consumers that the quantities, both of "Crown" bars and the better grades, available for their use are now practically nil, despite their constant requests for supplies. The requirements for war purposes, however, show no falling-off, and alike in the iron and steel departments the most intense activity prevails, while in many of the works shell discard steel is being rolled in great quantity, although at best it falls far short of the malleable iron which won name and fame for itself in former days. All outputs, of course, are under Government control and supervision, the bulk naturally being earmarked for Government contracts.

Scotch Pig-Iron Trade.—Little or no change falls to be recorded in the conditions ruling in the pig-iron industry; it is still a tale of intense pressure and of large output. Eager demand exists for every quality, the abnormal requests for hematite still being a prominent feature of the trade. Makers are therefore putting forth renewed efforts to meet these requirements, no easy matter when the different restrictions have to be taken into consideration. The local steel works rapidly absorb the entire output of hematite, so that with the continued strong demand for forge quality only a moderate quantity is available either for ordinary home consumption or for export. Rates continue firm and steady.

Shipbuilding Workers and Increase of Wages.—The general advance of wages made by the Committee on Production to workers in the shipbuilding trades, on July 14 last, has not quite met with the approval of those most intimately concerned, and a resolution protesting against the inadequacy of the advance has just been passed by the Clyde District Committee of the Engineering and Shipbuilding Trades' Federation. It is asserted that the recent advance in no way meets the increased cost of living, and the national executive has been asked to call a conference to deal with the matter and frame a resolution in accordance with the members' demands.

Shipbuilding Extension in Greenock.—A further step has taken place in connection with the desired extension of the shipbuilding and engineering yard of Messrs. Caird and Co., Greenock, a concern, of course, in which Messrs. Harland and Wolff have now a considerable interest. It has been intimated that the firm has purchased Seafield House and grounds, a large and imposing mansion situated at the east end of the Greenock Esplanade, and has offered this to the Old West Kirk, Greenock, as a site to which the church buildings might be removed. Meantime a committee has been appointed by the church trustees to discuss the question with the firm. Built about 80 years ago, Seafield House was for a lengthened period the residence of one after another of the most prominent shipbuilders in the Greenock district, amongst others who occupied it for some years being the late Mr. James Tennant Caird, father of the present representatives of the Greenock shipbuilding family whose enterprise and business acumen has done so much for the prosperity and development of the shipbuilding industry on the Clyde.

Interest Chart.—Messrs. Marsden and Co. have issued, at the price of 2*s.*, a chart showing graphically the return on any amount of capital for any period at 15 different rates of interest. Those who have frequent occasion to make rough estimates of this kind will find the chart a great saver of time.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The pits are again all working at their maximum, and with the works in full swing after the holidays the demand is steady and continuous. Steam coal is being well taken up for Admiralty and for industrial purposes and the surplus left for export is small. A moderate tonnage, however, is being shipped to France and Italy. All the rest is going away from day to day to railway companies, munition works, blast-furnaces, and other contract consumers. With the approach of September 10, when the new scheme to facilitate transport comes into force, merchants are anxiously discussing the various proposals with the different Control Boards. Sheffield, lying on the very borders of Yorkshire, was very badly hit by being shut off from Nottinghamshire and Derbyshire, whence she drew fully 75 per cent. of her supplies. An impossible position has, however, been eased by a modification of the Order whereby Sheffield is made an area to herself so far as manufacturing fuel is concerned. Cobbles, nuts and slacks are actively sought for and the whole output absorbed. Household qualities are in unprecedented demand, merchants being inundated with orders. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton.

Iron and Steel.—There is still great pressure upon the various branches of steel manufacture, the hot weather and recent holidays having had a tendency to lessen the production of furnaces, mills and forges. In most branches the demand is greater than ever. Practically the whole of the production is for war work, and though the export trade has somewhat slackened in certain branches, there has been a substantial advance in others. The increasing development of war in the air is causing an enormous demand for all mechanical parts necessary in aeroplane manufacture, and not only are departments which specialise in these full of work, but extensions are rapidly being made which will have a marked effect on the output later in the year. The activity in marine engineering is also giving an impetus to the demand for castings of all descriptions. The call for castings and forgings for this class of machinery is substantially greater than at any period during the war. Sheffield furnaces continue to concentrate their energies on acid steel and plants are working to their full extent. A large tonnage of basic qualities is also reaching the city. The surplus, however, after Government requirements have been satisfied, is of a negligible character. Makers report a somewhat easier demand for high-speed tool steel, but though the pressure is less evident, any surplus on the market is rapidly taken up. The latest War Office contracts include substantial supplies of railway springs, wheels and axles, as well as heavy indents for tools of all descriptions. Export business would be brisk but for the disabilities caused by the fighting. An order recently placed is for three 6-ton electric steel furnaces of the Greaves-Etchell type for installation in the United States.

Master Cutler.—At the meeting of the Cutlers' Company of Hallamshire, held at Sheffield on Tuesday, the Master Cutler, Mr. W. H. Ellis, was re-elected for the fourth successive year. This is the first time in the history of the company that the same gentleman has been appointed Master Cutler for four years in succession, but the Company is so closely identified with war administration that it has been found inexpedient in the national interest to make any change. The installation will take place on Thursday, October 4.

BRASS TURNINGS, BORINGS OR SCRAP.—The Ministry of Munitions announces that, in future, manufacturers will not be permitted to obtain supplies of brass turnings or borings of any kind, or of brass scrap, arising from the manufacture of munitions, from any source except the Ministry. All inquiries in this connection must be sent to 8, Northumberland-avenue, London, W.C. 2, under reference A.M.2.S.

SCYTHES FOR RUSSIA.—The American Export Steel Company, of New York, are now rushing through an order of half a million scythes for the Russian Government. These scythes will be distributed without charge by the Russian Government to the peasants throughout the various "zemsky sklads" or representatives of the "skhods" or peasant district assemblies. They have been made to the particular requirements of the Russian mower or "kossar," and are of a special and distinctive type. A peculiar custom of Russian mowers is to "hammer-sharpen" a scythe. The market in normal times was largely supplied from Austria.

A YEAR'S RAILWAY ACCIDENTS.—An official report just issued shows that the number of persons killed on our railways during 1916 was 1,066, as compared with 1,469 in the previous year. Of these casualties 159 were passengers, 453 persons employed on the railways, and of the remainder 310 were trespassers. The injured numbered but 5,589, which is an extraordinary decrease as compared with the previous year, when the total was 31,740. The difference is due to the fact that last year only those accidents consequent on the movement of trains of vehicles were included in the return, save in case of actual death.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The very plentiful supply of Cleveland pig-iron is added to by the closing of local consuming works this week for the race holidays. Home consumers are very well placed and can now afford to hold off buying until the September allocations. Whilst for the time being local deliveries are very small, large quantities are being steadily dispatched to other districts, and particularly to Scotland. The export trade is steady, and the better tonnage position is facilitating shipments to some extent. No difficulty is now experienced in securing licences for export of reasonable quantities to our Allies. For home consumption No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge are all quoted 92*s.* 6*d.*, and No. 1 is 96*s.* 6*d.*; and for shipment to France and to Italy No. 3 is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.*

Hematite Iron.—Conditions in the East Coast hematite branch are stringent. Very careful distribution is expected to continue to assure adequate supplies to home consumers and to leave a little surplus iron for export. Occasional home sales are recorded, but new foreign business is stagnant, and export quotations are nominal. Against old contracts everything possible is being done to facilitate shipment of iron already licensed for delivery to our Allies, but it is fully recognised that future allocations cannot be heavy. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, and nominally 137*s.* 6*d.* and 142*s.* 6*d.* for export to France and Italy respectively.

Foreign Ore.—Deliveries of foreign ore have been interrupted, so far as Bilbao qualities are concerned, by the strike in Spain, but not to the extent of handicapping at all the working of blast-furnaces. A fairly steady business is reported in other foreign ores.

Coke.—The very ample supply of coke has no apparent weakening influence on quotations of descriptions needed for the blast-furnaces. Local demand keeps heavy, and average furnace kinds still command the fixed maximum of 28*s.* at the ovens; whilst qualities low in phosphorus remain at the limitation price of 30*s.* 6*d.*

Manufactured Iron and Steel.—Works are closed this week, as is customary at local race time, and opportunity is being taken of carrying out much-needed renewals and repairs to plant which has been continuously in operation for a lengthy period. These will assist towards greater efficiency in the future. No new features of moment are noticeable in the various departments. Quotations, all round, are steady and firm. To home customers common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; double best bars, 14*l.* 10*s.*; treble best bars, 14*l.* 17*s.* 6*d.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 18*l.*; packing iron and steel (parallel), 13*l.*; packing iron and steel (tapered), 15*l.* 5*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.* and upward; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 15*l.* 10*s.*; and heavy steel rails, 10*l.* 17*s.* 6*d.*

EXPLOSION OF AN OXYGEN CYLINDER.—A peculiar case of an explosion of an oxygen cylinder, which unfortunately killed three men and wounded many others, is described by Professor L. Wöhler in the *Zeitschrift für Angewandte Chemie*, of July 10, 1917. Such accidents had ceased when, years ago, right-handed threads were adopted for the oxygen cylinders and left-handed threads for the hydrogen vessels, and the two were moreover distinguished by being painted red or black. The case, which seems to be due to carelessness under the stress of work by inexperienced men, is the following: A chemist noticed that an oxygen cylinder supplied to him by a firm of standing contained some hydrogen. He returned the cylinder, which was then re-charged with oxygen without having been emptied and examined. When used afterwards for acetylene welding it exploded with the result stated, a piece of steel cutting through an oxygen bottle near it and bending that cylinder, and smaller fragments piercing the locomotive in the yard as if it had been under rifle fire. The explosion had the character of a shell explosion. Professor Wöhler found out that, temporarily, steel nuts had been used, hard enough not only to force their way into a wrong thread, but actually to reverse the thread. Wöhler convinced himself by experiment that this was quite possible. The thread in the cylinder in question had been split in this way, and the improper brass nut had then fitted into the wrong bottle; it was an old cylinder, moreover, no longer showing any distinct colouring. The regulations were evidently disregarded in several respects; the gases themselves were all right, the oxygen having been made from liquid air. The strange thing was that the blow-pipe nozzle, the tubing, the reduction valve and the cylinder valve remained almost intact; this fact seems to exclude the probability of ignition in the cylinder; the explosion probably travelled back from the flame. In this connection Wöhler mentions a recent laboratory experience of his. He was charging hydrogen from a big cylinder into a smaller one through a connecting tube of brass. The valve of the small bottle was open; when he opened that of the large cylinder, nothing happened for a few seconds. Then a slight explosion occurred, the tube was blown off, and flames shot out of both the cylinders. There was no flame or anything giving sparks near the apparatus, and Wöhler suggests that the hydrogen, rushing into the small bottle, which contained air, was electrified by friction and ignited in that way.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Owing to the tippers' strike, coal shipments at Barry Docks were at a standstill at the beginning of this week. The stoppage led to the diversion of tonnage to the Bute and Penarth Docks, and also to Newport. These docks were able to deal with the available shipping. Business for ordinary coal export has been very idle, but prompt supplies were a little more plentiful this week. Fortunately the men agreed to resume work on Wednesday morning, pending arbitration on disputed points. The middleman is having less and less to do, and though the Coal and Shipping Controllers are doubtless innocent of any deliberate intention to eliminate the exporter, broker and dealer, their Orders are none the less producing this effect to an increasing extent. This is a regrettable consequence of State control. Till a few weeks ago it was the evident policy of the Government to retain at least a skeleton of the pre-war private commercial organisation of our overseas trade. That was unquestionably a wise precaution, for when the war ends we shall want the service of every unit of trading power to recover the ground we have lost during the past three years; but it is not a precaution that is being adopted in the case of the coal export trade.

Newport.—Over the week end there was a fair arrival of tonnage, with the result that collieries were reported fully at work this week. The strength of the better classes of Eastern and Western Valleys coal is well maintained, but the lower grade small coals are a shade easier. There is no change in pitwood.

Revision of Coal Prices Schedule.—The Controller has agreed to a revision of his original schedule for anthracite, steam and bituminous coals shipped from Swansea, and business is already taking on the basis of the new graded prices. In the scheme of June last Swansea steam coals were split up into two grades for large, one for throughs and one for small, and bituminous coals into two grades—one for through and another for small coals. In the new list three classes are added to the steam coal schedule; and under the heading of bituminous coals new grades for through and small gas-coals are included. The chief changes are the elimination of the original grade of 25*s.* for all qualities of through bunker coals, the incorporation of through cargoes and through bunkers at a uniform price of 23*s.* 6*d.*, the inclusion of a second class of cargo throughs at 22*s.*, and of a new class of second smalls at 17*s.* The prices for gas (through) at 23*s.* 6*d.* and gas smalls at 21*s.* are also new, while among the anthracite prices that of breaker duff is reduced from 10*s.* to 8*s.* The Controller has agreed to these changes as the result of the representation of the sub-committee appointed to deal with the classification of coals for the purposes of the scheme. These alterations remove some of the grievances of the colliery owners and exporters in the Swansea and West Wales areas. Coal-owners and exporters in the Cardiff and Newport districts have also been in communication with the Coal Controller as to the advisability of the extension of the grades applicable to the through and small coals exported at Cardiff and Newport. It had been arranged that a deputation should wait on Mr. Calthrop on Tuesday of this week, but the appointment was abandoned in view of an intimation from Mr. Calthrop that he is agreeable to a revision of the schedule as applied to Cardiff and Newport, on the condition that the colliery owners and the other parties immediately concerned can come to an agreement on the proposed new prices. The Classification Committee are, therefore, meeting this week, and the probabilities are that one of the immediate results of the arrangement of a revised and more extended list of graded small coals will be the inclusion of patent fuel in the Controller's scheme.

THE INDIA RUBBER, GUTTA PERCHA AND TELEGRAPH WORKS COMPANY, LIMITED.—Early reports of the fire which took place at the works of the India Rubber Company, Silvertown, on the 11th inst., appear to have been greatly exaggerated. Comparatively little damage was caused, and there was practically no disturbance to the manufacturing operations in the building involved.

PROFESSOR OF MECHANICAL ENGINEERING IN THE UNIVERSITY OF MANCHESTER.—We are pleased to learn of the appointment as Professor of Mechanical Engineering in the Faculty of Technology of the University of Manchester of Mr. Gerald Stoney, F.R.S., M.Inst.C.E., who was so long and intimately associated with Sir Charles Parsons in the development of the steam turbine and who has contributed many valuable and informing papers to technical literature on mechanical engineering. After September 6, Professor Stoney's business address will be School of Technology, Whitworth-street, Manchester, and his private address Parrs Wood Hotel, East Didsbury, Manchester.

THE FORGING PRESS AND THE STEAM HAMMER.—In a paper published in *The Blast Furnace and Steel Plant* Mr. J. L. Cox observes that with all its advantages, such as convenience of handling and absence of shock, the press has two failings. In the first place it is harder to get rid of scale, which is dislodged by the impact of a hammer, and it cannot strike in a mould as large a forging as a hammer its equivalent in other respects. The Midvale Steel Company consider a 500-ton press as the equivalent of a 2½-ton hammer, a 1,200-ton press as equal to a 10-ton hammer and a 2,500-ton press as equivalent to a 25-ton hammer. Nevertheless, a 4½-ton hammer can make drop-forgings beyond the capacity of a 1,200-ton press, which in this respect is about equal to a 2½-ton hammer.

THE ARRANGEMENT OF MACHINE SHOPS.

(*For Description, see Page* 191.)

Fig. 162. Erecting Floor for Gear-Cutting Machines; Brown and Sharpe Manufacturing Company, Providence, R.I., U.S.A.

Fig. 163. Assembling Department for Milling Machines; Brown and Sharpe Manufacturing Company, Providence, R.I., U.S.A.

THE "BEARDMORE" MARINE OIL ENGINE.

CONSTRUCTED BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, NAVAL CONSTRUCTION WORKS, DALMUIR.

(*For Description, see Page* 194.)

Fig. 1

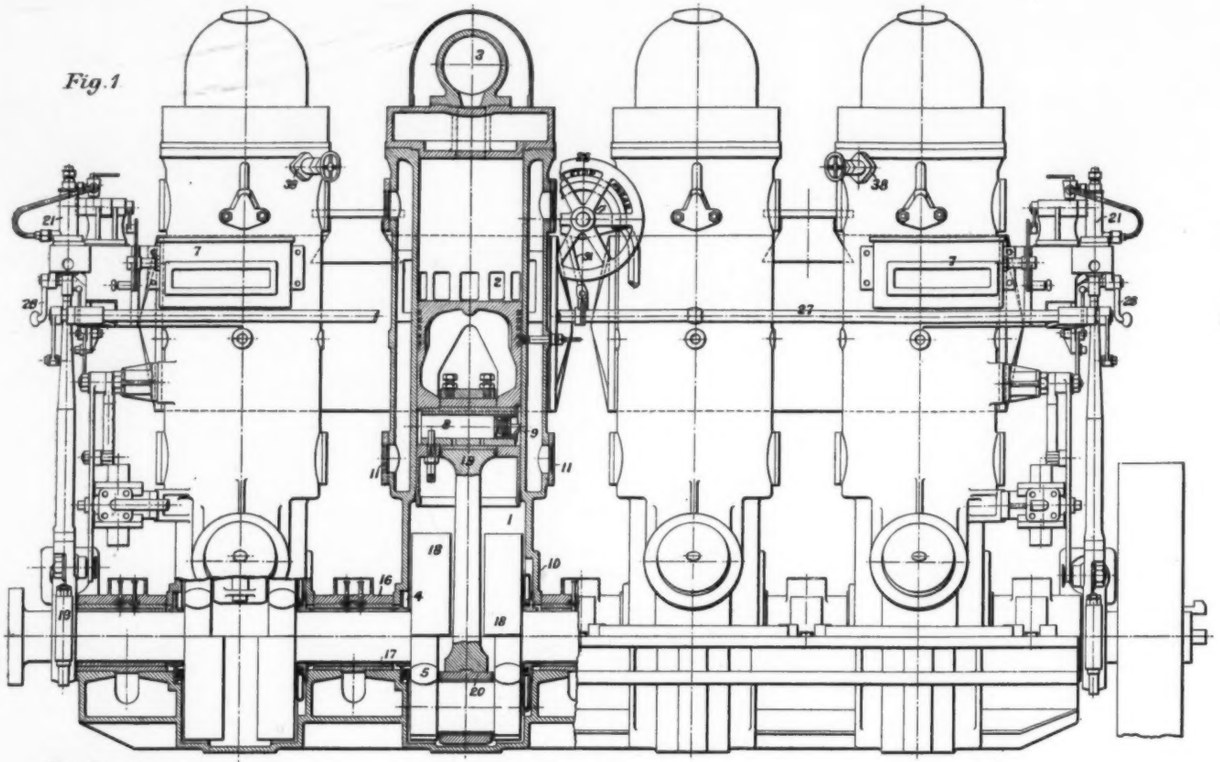
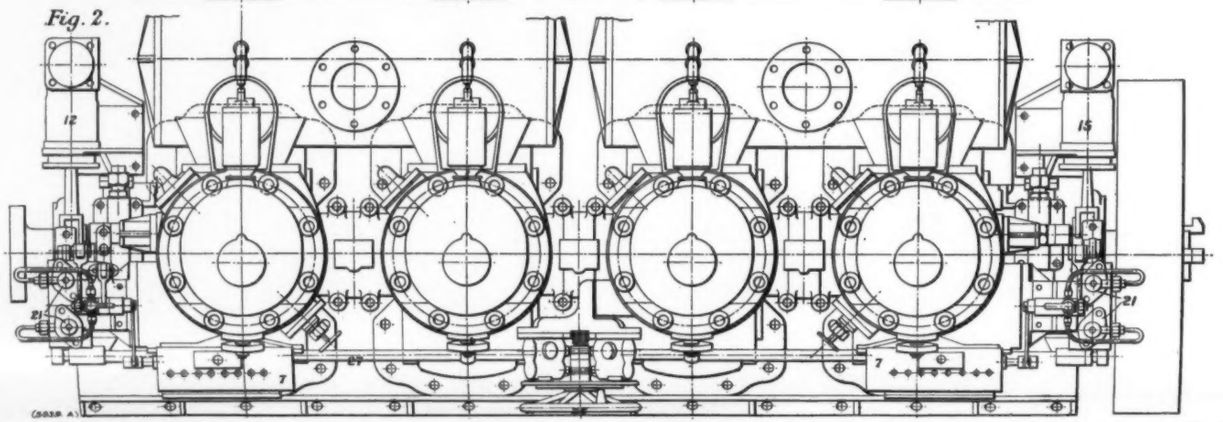


Fig. 2.



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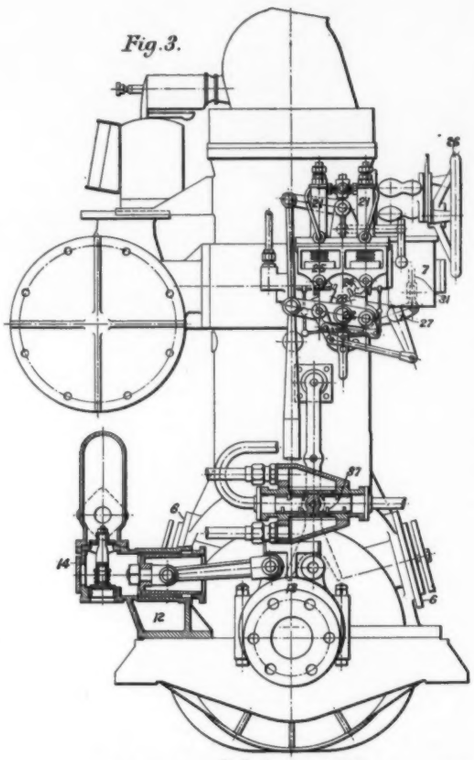

Scale for Figs 1, 2 & 3.

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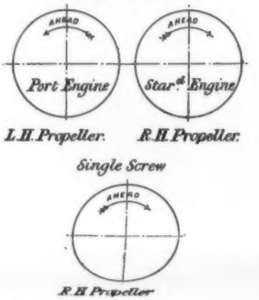
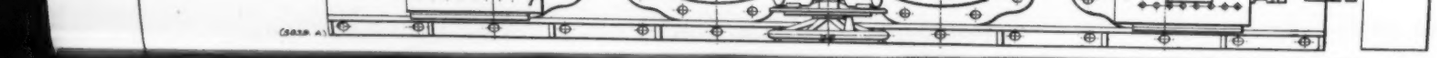
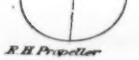
DIRECTIONS OF ROTATION, LOOKING FORWARD.

Fig. 4.







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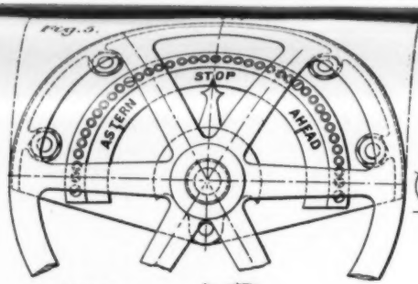
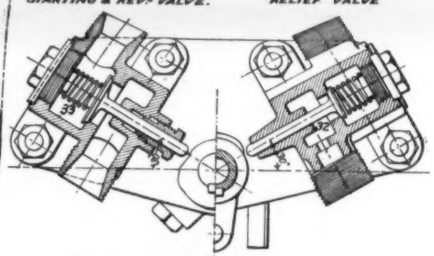


Fig. 4.
SECTION THROUGH STARTING & REVS VALVE.

Fig. 5.
SECTION THROUGH RELIEF VALVE



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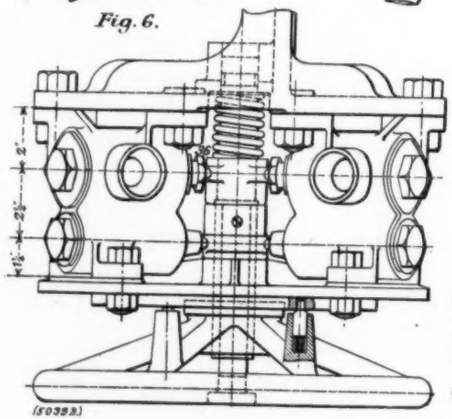

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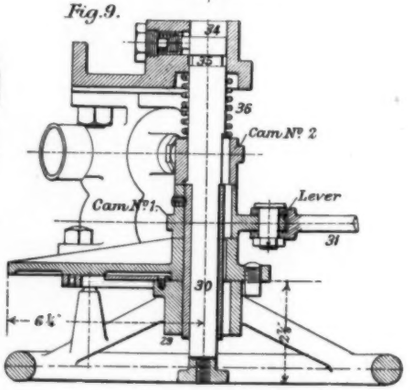


Fig. 10. POWER CARD AT 280 REVS.

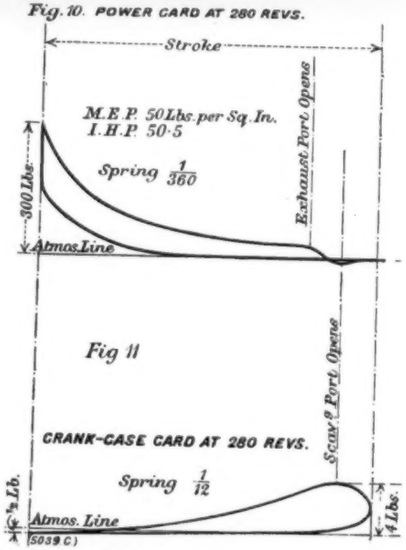


Fig. 12.

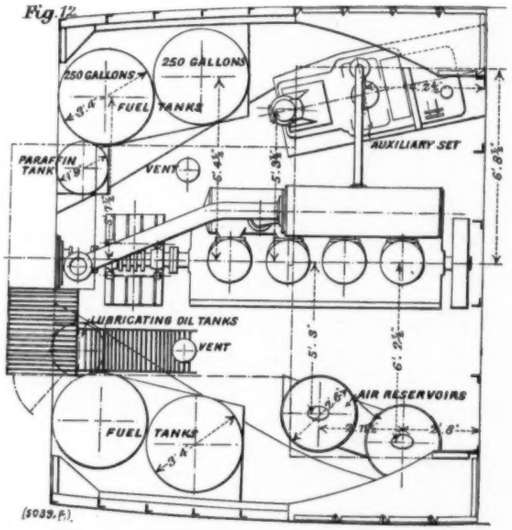


Fig. 13. SECTION AT FRAME 7. (LOOKING FORWARD)

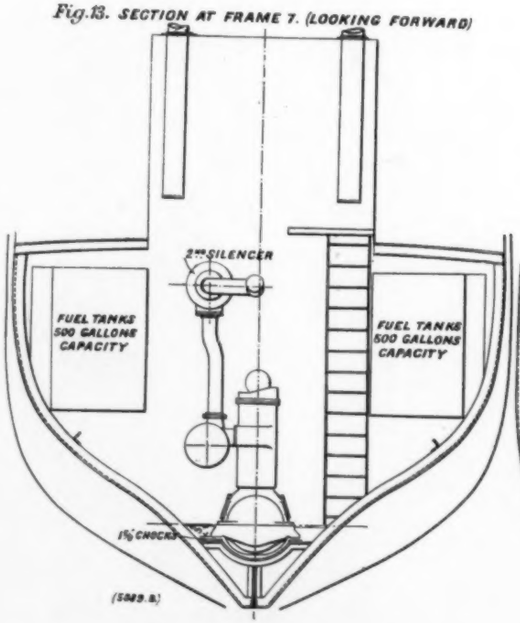


Fig. 14. SECTION AT FRAME 13. (LOOKING FORWARD).

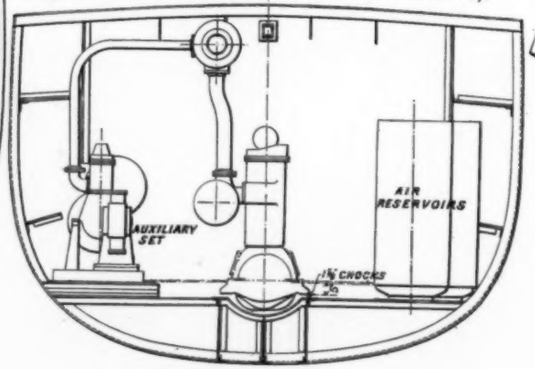
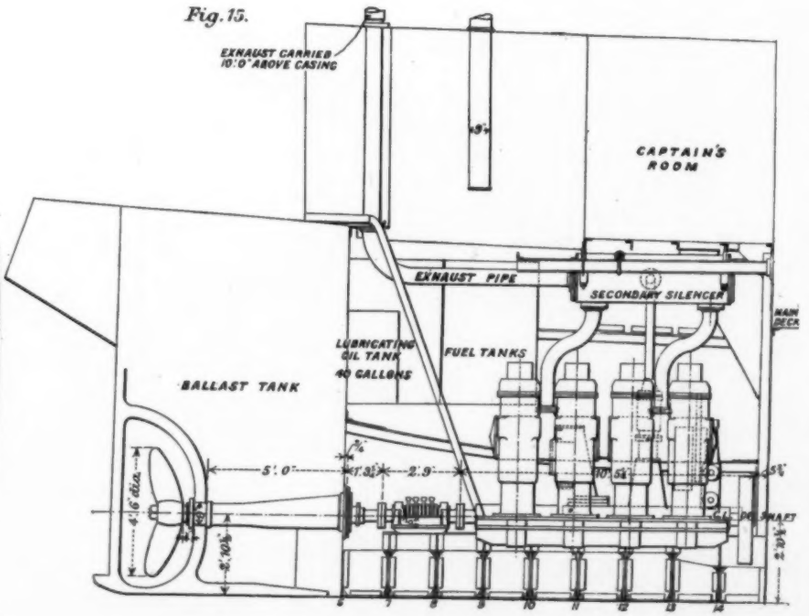


Fig. 15.



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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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With a Two-Page Plate of the "BEARDMORE" MARINE OIL ENGINE.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

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In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, AUGUST 24, 1917.

THE ART OF LIVING.

IN his first presidential address before the Institution of Mechanical Engineers Dr. Unwin quoted a saying of Samuel Butler to the effect that life is the art of drawing sufficient conclusions from insufficient premises. He then went on to apply this idea to the work of engineers, recalling the fact that in the solution of engineering problems there are always many factors which are incompletely known, and about which it is necessary to make assumptions which in some cases are really guesses. Butler's aphorism, however, is far from being a complete statement of the case. The drawing of conclusions, however sufficient, is not life, since life, for practical purposes, implies motion or action of some kind. In certain subjects, for instance in philosophy, it is not possible to give effect to conclusions, and all that they lead to is a sense of satisfaction at having settled some doubtful question and freed the mind from the worry of uncertainty. They may thus set the energies at liberty to expend themselves in other directions. The same result is, however, sometimes attained by ignoring all problems that do not lead to results which can be subjected to experimental verification, and this is vastly simpler. Professor Huxley took this attitude when he invented the term agnostic for himself and refused to yield to the custom of drawing conclusions from insufficient data in cases in which it was not possible to subject these conclusions to the test of experience. He is not likely to have many followers, for the human mind demands explanations of phenomena, and also of its fears and hopes. Astrologers and medicine men have thriven on this demand ever since the race existed, and will continue to do so. Already the word agnostic has almost lost its original meaning and is applied to those who have arrived at conclusions which are not generally considered orthodox.

It is instructive to notice Butler's choice of words. He does not say correct conclusions, but sufficient conclusions, and we know by experience that wonderful results can be attained by conclusions that are manifestly incorrect. The Christian Scientists have arrived, from premises that seem insufficient to most of us, at the conclusion that pain has no existence, and is only subjective. Some of them seem to be able to conduct their lives according to this conclusion, and to go about with smiling faces when evidently suffering from diseases which would lay other people aside. This suggests that the accuracy of conclusions is far less important than the sincerity with which they are held and the courage with which they are applied. Certainly there is much truth in this view as regards engineering problems. We do not suggest that success can be obtained from utterly fallacious conclusions, but it is quite certain that "sufficient conclusions" are useless unless they are held by a man who has the courage to bear the responsibility of advising his clients to risk their money in putting them into concrete form, and who at the same time has the faculty of inspiring confidence in his abilities. Many important designs, involving much skill and not a little mechanical instinct (as distinct from engineering knowledge), are got out by draughtsmen who are utterly incapable of carrying them into execution, except so far as drawings may be considered a stage in execution. They can arrive at sufficient conclusions from insufficient premises, but there they stick. Their work represents to them a balance of probabilities, but they are never certain that they have weighed each probability correctly. They know that they have done their best, but they are by no means certain that mistake has not crept in somewhere, and they have not the courage to go forward as if their plan were based on certitudes. What they need to do is, metaphorically, to burn their boats, trusting to their abilities to fight or outflank each difficulty as it is encountered, and this they have not the courage to do. They have not mastered the art of living in a complete sense.

Life does not consist so much in drawing conclusions as in acting upon them. It is coloured by the sufficiency or otherwise of the conclusions, but whatever that may be, the life may still be virile. Courage, resource and initiative are the qualities that enable a man to fill a great part in the world. When they are combined with the faculty of drawing sufficient conclusions from insufficient premises we have a Napoleon, the man who can discover opportunities, or create them if they do not exist. The great thing is that a man have the courage to do something, to enter into the conflict with Nature and attempt to direct her forces into hitherto unattempted channels. Sometimes they will refuse his guidance, and then he will need to take comfort from the proverb "He who has never made a mistake has achieved nothing."

The mention of Napoleon recalls the fact that it is in military affairs that the faculty of forming sufficient conclusions from insufficient premises counts most. Wellington was once driving with a friend through an unfamiliar country, and the two amused themselves by guessing what they would find beyond each turn of the road. Wellington was by far the more successful of the two, and explained the fact by saying that a great part of his life had been passed in guessing what was happening "on the other side of the hill. The construction of the lines at Torres Vedras shows that he guessed rightly that his opponent would drive him back to the sea, while it also demonstrates that Massena never anticipated that Wellington had constructed an impregnable fortress into which to retreat. On the other hand, Wellington made a bad guess when he kept 18,000 men on the Mons road during the battle of Waterloo, on the assumption that Napoleon would endeavour to turn his right flank. Those men would have been very useful in the battle, and would have rendered Wellington much less dependent on Blucher's aid. However, he won the day, and this was what he set out to do.

The engineer, unlike the military man, does not guess in competition with an opponent like himself. He guesses against Nature, and although this is a redoubtable antagonist it, at any rate, plays no tricks. Under uniform conditions its action is uniform. Unfortunately conditions are very seldom uniform, and it is often quite impossible to determine beforehand either what they are, or how they will affect other and calculable forces of which they will form the environment. Often it is quite impossible to draw conclusions very far ahead. The work must be commenced in a tentative fashion, akin to the surgeon's exploratory incision, and data must be sought as it proceeds. This is research work on an heroic scale, and needs not only skill and initiative, but immense courage and self-confidence. It also involves great anxiety and a load of responsibility which only a strong man can carry. Strength is the product of effort; it grows the more it is exercised. But there are limits peculiar to each individual; it is not everyone that is born with the possibility of becoming a Samson, even with the most constant effort. We do not for one moment suggest that the art of living is a sealed book to such men. They can, and often do, carry the full load of responsibility which their mental physique will permit, and perform most useful work in the world. Sir Maurice Fitzmaurice, in his presidential address before the Institution of Civil Engineers last November, bore generous testimony to the value of subordinates who perform

their duty conscientiously and loyally, and he incidentally hinted that the resident engineer may live a happier and pleasanter life than his chief, even though the latter may be looking forward to filling the presidential chair.

In that remarkable series of articles on the war which appeared in the *Spectator* under the name of "A Student in Arms," there appears the following statement: "To know one's limitations is a mark of wisdom; to rest content with them merits contempt. There is no dishonour in a humble lot—unless one is shirking the responsibilities of one more exalted." This sums up the whole matter of the art of living. Each needs to live as fully as he can, but never to be satisfied that he has attained to his complete development. If he can draw sufficient conclusions on a certain subject and can put them on paper he has accomplished a good deal, even if he cannot carry them forward into concrete form. He has, at any rate, released someone of stronger fibre to do the rougher and more adventurous part of the work, just as the woman munition worker contributes something to the perilous duty of the trenches when she undertakes a man's task at the lathe. Some day the humble worker may develop greater strength, and so make progress in the art of living. So long as he is not satisfied that his conclusions shall be merely "sufficient," and strives to attain closer and closer approximation to exactitude even on paper, without attempting the more perilous problem of putting them into concrete form, he displays the fruits of vitality. Of course we are writing as engineers. To us material matters are of high importance, but we must never forget that mankind, in spite of its animal instincts, never fails in the long run to rank spirit above matter. The Germans thought that we were given up to luxury and the pursuit of wealth, and they laid their plans on that assumption. There were also many in this country who sorrowfully accepted the same view, but events proved that they and the Germans were alike wrong. At the sight of outraged Belgium politicians forgot their struggles for power, men of pleasure buckled to stern work, trade unionists surrendered their hard-earned privileges, and women of fashion abandoned their frivolous pursuits for nursing and munition making. Like the ancient Israelites, the British nation chose the simple manna of the desert in preference to the flesh-pots of Egypt, and they have never repented of their decision, although it has cost them blood and gold beyond measure. So far the conclusions of the prophets have proved quite insufficient, not to say misleading, but even if the success we still confidently look for were to be lacking, the verdict of humanity would be that we did the right thing. The failure to attain to a high ideal is better than contentment with a low one. The dead warrior is a far better exponent of the art of living than the contented slave, although the latter, from a material point of view, has drawn the more sufficient conclusions.

A MUNITIONS COUNCIL AT THE MINISTRY OF MUNITIONS.

We have frequently had occasion to offer criticism regarding the operations of the Ministry of Munitions as well as to bestow well-merited praise. The department was of mushroom growth, and had to tackle problems for which there was not the help of precedents to guide towards matured solutions. Moreover, the demands on the Ministry were colossal and of vital urgency, the necessity being to provide the army with the required volume and variety of munitions of war and to hope for the best in respect of economy and internal efficiency. The principal difficulty experienced in the quick growth of departments was a lack of co-ordination, with consequent overlapping, so that one branch of the service was competing against another, either for material or for labour. Another serious hindrance to adequate production was the unsuitability of many of the men for the positions in which they were placed. We do not mean to imply that incapable men were selected, but rather that their training and experience, however satisfactory in some walks of industrial life, did not fit them for the positions into which they were literally forced. This applies to almost every rank in the Ministry of Munitions army, and in no department more markedly than in the work of inspection. Indeed, we might go so far as to say, again, that in the case of highly responsible and completely experienced firms detailed inspection might better have been dispensed with.

In view of all this we welcome the establishment, as from Monday last, of a Council of Chiefs of Departments under the presidency of the Minister of Munitions, or, failing him, of his deputies, which will be analogous to the Board of Admiralty and the Army Council. This "Munitions Council" will be made up of the Minister as president, of the two Parliamentary Secretaries as vice-presidents, and of ten members, each representing a group of departments of the Ministry, together with the secretary. The first composition of the Board is satisfactory. With the technical members we are here more concerned, and of these probably the most satisfactory appointments are those of Mr. John Hunter, who continues to take charge of the Steel and Iron Department; Sir Ernest Moir, Bart., who is concerned with materials, &c.; Sir Keith Price, who deals with explosives; Sir Glynn West, with guns; and Sir Arthur Duckham, K.C.B., with engines; while Sir Frederick Black, K.C.B. (whose place is at present taken temporarily by Sir Charles Ellis, K.C.B.) deals with supplies for the Allies. All of these engineers have been at the Ministry of Munitions for a long time, and have shown, by their technical knowledge and organising ability, the qualities which justify their inclusion in the new Munitions Council. The idea is obviously that in all matters of administration and superintendence each officer will be supreme in his own department, and to this extent there will consequently be decentralisation so far as decisions in connection with details are concerned and centralisation so far as each department is concerned; while the inclusion of these in the Munitions Council will ensure that measure of co-ordination between departments which is essential. The official notification states that "the position of a member of the Council in relation to his group of departments will be: (i) To superintend generally the work of the group and to consider in the first instance all important questions upon which the head of the department requires assistance or rulings, such as those which would previously have been submitted to the Minister or through the Parliamentary Secretaries, and either to decide on the Minister's behalf such questions or to refer them to the Minister with a recommendation as to the decision; and (ii) to exercise such administrative functions through the heads of departments in his group as are necessary to ensure that the policy of the Minister is carried out." Important questions involving more than one group of departments will be considered at committee meetings and conferences which the members of the Council representing the groups concerned will attend.

The members of the Council concerned will generally be present at the conferences held by the Minister with heads of departments, or with associations, public bodies, &c. These, we presume, will include meetings in connection with labour, and in connection with this one matter a great gain must result. The Ministry of Munitions, it may be stated, now employs about 2,000,000 persons in controlled works, apart altogether from the 13,500 members of the staff at headquarters, and it will be recognised that efficiency as well as economy must be greatly influenced by the correct control of these 2,000,000 workers. That there is room for improvement in this respect it would be easy to show, but even a small fraction of saving would be material, as the Ministry is responsible for the expenditure of between 600,000,000*l.* and 700,000,000*l.* a year.

An indispensable feature in connection with the new organisation is the Secretary's Department, and a Council Secretariat is to be established under Sir Graham Greene, the new Secretary of the Ministry of Munitions. This department, it would seem, is to be responsible for the direction and distribution of the flow of official papers among all the departments, and for the means taken to concert the action of the various departments and authorities in each class of business, the recording of action, and the circulation of information of all kinds. In the past there has certainly been delay in connection with communications to the Ministry, owing to the difficulty of correspondents knowing to which department to direct their inquiries. If under the new secretariat there is less confusion and time is saved, business will be expedited, and those working for the Ministry will be gratified. We do not for a moment overestimate the importance of the secretariat when we say that much of the benefit which can arise from the re-formation of the Ministry depends on the prompt dealing with correspondence by this secretariat. We have used the official words, "flow of official papers among all the departments," and we trust that there will be in the secretaries' department no damming up or eddying in this flow. This is vital to the success of Mr. Churchill's new organisation.

ALKALI WORKS IN 1916.

The fifty-third annual report on alkali works, for the year 1916, presented by the chief inspector, Mr. W. S. Curphey, to the Local Government Board and to the Secretary for Scotland, differs from its predecessors in one important respect. The inspectors' reports for the 10 district areas under inspection (numbered 1 to 7, with additional numbers 3A, 4A, 6A) are not reproduced at all this year, after having been curtailed for the sake of economy last year. This applies also to Scotland, though that report is kept apart from those concerning England, Wales and Ireland. The omission will be regretted, especially by those interested in particular works or industries; but the chief inspector had the reports of the inspectors before him, of course, when drawing up his summary. In other respects war conditions have also influenced the industry and the work of the inspectors more profoundly in 1916 than in the previous year. There was enormously increased activity in some fields, especially in high explosives, old plants were enlarged and new plants opened, not infrequently with insufficient skilled labour, and the heavier burden of inspection fell upon a staff depleted by the death of Mr. E. Jackson, by the loss of the services of Mr. A. C. Carter (on military duty), by the transfer to the Ministry of Munitions of Messrs. H. J. Bailey and H. Porter, and by the temporary attachment of Dr. T. L. Bailey to that department. Mr. Linder, Mr. Curphey's assistant, shared the duties of the inspectors; the names of the other inspectors will be mentioned in this account. The pollution of the atmosphere by works could not always be kept within the legal limits under the circumstances, and the forbearance of the inspectors had often to be claimed. Proceedings for contravention of the Alkali Act, due to unsatisfactory conduct of registrable operations, were not taken, however—none have been taken for many years, in fact—and in two instances where registrable processes were carried on in unregistered works back fees were accepted without going to law with the object of enforcing penalties. Some complaints by the public about pollution of the air were found quite justified; the noxious gases came from low-level escapes rather than from the chimneys. In other cases the public was perhaps more alarmed and annoyed by increased smoke than by poisonous gases; the report does not refer to smoke.

Compared with 1915 there was an increase of 3 in the number of registered alkali works, and of 18 in other works, a total increase of 21, bringing the alkali works up to 66 (against 63 and 68 in 1915 and 1914) and the scheduled and registered works up to 1,327 (against 1,309 and 1,288); in Scotland the number of registered works decreased by 3, to 167. In most of these works more than one registered process is carried on, of course, and the statistics of processes for 1916, 1915 and 1914 are 2,253, 2,125, 2,044; in Scotland the number of processes was 315 (310 in 1915).

As regards alkali (wet process) works the general average escape of muriatic acid from chimneys, &c., amounted to 0.086 grain per cubic foot, which is well within the legal limit of 0.20 grain, though the limit was sometimes exceeded. The use of nitre-cake (acid sodium sulphate containing sulphuric acid and also nitric acid) instead of sulphuric acid for decomposing salt in salt-cake furnaces (and also

for making superphosphates, etc.), decreased the proportion of hydrochloric acid per ton of salt-cake produced. Mr. Littlefield reports on the introduction of a new type of muffle furnace for making salt and nitre cake; there were considerable difficulties with the mechanical feed, and so far the yield was not satisfactory. Mr. Fletcher mentions that with nitre-cake there is a less violent reaction and less evolution of fluorine compounds; but both he and Mr. Littlefield speak only of a few works in which nitre-cake was used on a large scale. A case of local heating of alkali waste is mentioned by Mr. J. W. Young, from Scotland; the deposition of waste had been discontinued for some time.

The acidity of chimney gases from smelting works, always higher than that from other works, decreased a little in 1916 (to 3.01 grains of SO_3 per cubic foot); the acidity from other chimneys increased a little (to 0.932 grains of SO_3). The number of smelting works diminished slightly (from 75 to 71), two of the works taking up munition materials. In tin-smelting and arsenic-recovery works the gases are passed over limestone and through milk of lime, with satisfactory results. There is an interesting reference to tungsten. Cornwall, Dr. Fryer points out, now produces three times as much wolframite (tungsten ore) as Austria and Germany did before the war, though they controlled the tungsten market; the wolframite occurs with cassiterite (tin ore) in Cornwall. The above-mentioned reduction in the SO_3 contents of the chimneys was partly due to the increased production of sulphuric acid from zinc sulphide; this production would have been greater if there had not been trouble with the operation of mechanical calcining furnaces and with the scarcity of labour for special forms of hand furnaces. Calcining furnaces of various designs for zinc sulphide were under trial in many districts of the north and west of the kingdom; Mr. Curphey remarks, however, that mechanical furnaces of this type may still be regarded as in the introductory stage, as they differ materially from the pyrites burners used by the sulphuric acid maker. Very extensive additions were made to zinc works, but new works were not actually started, though several were projected. One very busy zinc plant in Scotland gave rise to repeated complaints owing to the escape of fumes; prolongs were introduced to arrest the fumes leaving the receivers for the condensed zinc; the prolongs stopped over 1 ton of solid dust daily which would otherwise have been lost and discharged into the air, but further improvements were still desirable. The number of zinc extraction works has been 12 since 1914. Experiments on the electric precipitation of fumes and dust were alluded to in our notice of the alkali inspector's report of last year (see ENGINEERING, October 13, 1916, page 361); this year's report says that further successful experience was gained in electrical and mechanical appliances of this kind, but no great extension in practical working was made during the stress of the abnormal times. Cement works decreased by 7, and many of the 49 remaining works were only in partial operation; the question of potash recovery has not advanced.

The escape of SO_3 gases from lead chambers amounted to 1.269 grains per cub. ft. on the average (1.137 in 1915), but fluctuated a good deal (the maximum figure recorded from one district is 9.88 grains) owing to excesses from a comparatively small number of works, where properly qualified chemists were not at command and proper records were not kept. Mr. Porter's work at the Ministry of Munitions helped to improve these matters. Attention is again drawn to the removal of coke from Gay-Lussac towers. At the Haford Works of Messrs. Vivian and Sons, Swansea, Mr. Madel had a tower well washed with acid and then with water by a 2-in. pipe, the latter washing liberating dense nitrous fumes, which were led to the Glover tower of another set; the washing was continued night and day for four days, until the water was practically free from acid, and a hole was afterwards cut through the brickwork below the outlet of the tower; the coke then ran out like flint, in loose pieces, without having to be broken up. Mr. Curphey considers that four days' washing would hardly be necessary in some cases. Some lead chambers were undoubtedly overworked, though others were not worked to full capacity. Among various possible ways of improving their capacity Mr. Curphey suggested, in 1915, that an iron contact tower should be inserted between the burners and the Glover towers, in order to relieve the chambers, and that a second series of burners, also provided with an iron contact tower, should be added to deal with a second quantity of sulphurous gases. Mr. Porter has now introduced this novelty in two works, with the further object of minimising dust trouble.

Class II sulphuric acid works (contact process) have further increased both in number (the figures for 1914, 1915, 1916 are 93, 112, 120) and in output of acid of the highest strength wanted for explosives. The "oleum" plants—oleum is sulphuric acid, H_2SO_4 containing an excess of the free anhydride, SO_3—are working with (1) iron oxide contacts, the unabsorbed gases being sent to lead chambers for further treatment; (2) iron contacts, the remaining gases being sent to platinum contacts for the further production of oleum; (3) platinum contacts. In case (1) trouble was first experienced from the sluggish action in the chambers of the gases coming from the contact section, as the gases were lowered in SO_2 concentration, temperature and moisture; this trouble was overcome by the judicious use of steam. The processes used are the Badische (the original contact system worked out by Knietsch in the Badische Anilin- und Soda-Fabrik, making use of platinised asbestos), the Mannheim (making use of iron oxide, which becomes active at 600 deg. C. only, whilst platinum catalyses at 450 deg. and less), and the Tenteleff (using platinum); the Schroeder-Grillo process (soluble platinum salts) was successfully introduced last year.

In the acid concentration works some new plants of inefficient design were chiefly responsible for the high escapes sometimes observed (up to 8.50 grains of SO_3 per cubic foot), the averages for 1916 and 1915 being 1.247 grains and 1.0 grain. Cascade plants gave most trouble; in these the strong acid flows downward from one long-lipped basin (of silica, tantiron, narki, &c., as noticed last year) into another, all the basins being heated from below; there was excessive boiling, especially when acid sulphate deposited in the basins, some basins cracked, and acid found its way into the fire flues. The concentration towers and pans (Kessler, Perrin, Gaillard and Duron) worked more satisfactorily, although one Gaillard tower led to undue escape, as it did last year. We should say, perhaps, that in Glover towers the SO_2 from the burners meets a stream of sulphuric acid containing nitrogen oxides on the counter-current principle, whilst Gay-Lussac towers serve for the absorption of the nitrous gases. Both types of towers are generally packed with silica, stone or coke, and combined in sulphuric acid works in various ways; the Gaillard towers are not packed. In the various Kessler apparatus the hot gases are drawn by a fan through sulphuric acid. Volvic lava from the Auvergne is one of the materials for modern tower construction. Dr. Fryer also refers to the Davis concentrator as a hopeful novelty; it consists of a chamber (15 ft. by 5 ft. by 2 ft. wide); the chamber is lined with lead, the acid flows in a stream of 3 in. depth, and is thrown up by paddles on the Porion system. A Thomas-Harris rectifying plant was not in regular use yet. The precipitation of acid vapours on the Cottrell system (by high-tension electric discharges) was still under trial, with promising results; the fumes from cascade units have also been reduced by supplying the fan (for inducing draught on the fume flue) with water or weak acid. An impressive feature of both these methods is that the gases are subject to the electric discharge or the fan action for only short periods.

Chemical manure works have been decreasing in number for seven years, the numbers for 1914, 1915, 1916 being 151, 144, 142; last year they worked intermittently; some had to use nitre-cake instead of acid, and the success there obtained is encouraging. The imports all went down, guano from 39,285 tons in 1914 to 21,644 tons in 1916, mineral phosphates similarly from 555,605 tons to 333,371 tons, and sodium nitrate from 171,910 tons to 20,896 tons; the exports of sulphate of ammonia also decreased; there were 259,800 tons in 1916 (leaving 178,000 tons for home consumption for all purposes), against 294,000 tons (128,000 for home consumption) in 1915. The number of works in the group dealing with sulphate and muriate of ammonia and gas-liquor works, on the other hand, continued to increase, there being 624, 628, 641 ammonia works and 56, 58, 81 gas-liquor works in 1914, 1915, 1916. The processes under inspection rose by 36 (over 1915) to 722. The amount of ammonia recovered as by-product has not changed much, however, the total figures for the same years being 426,412 tons, 426,267 tons and 433,703 tons (expressed in terms of sulphate); this sulphate comes mostly from gas works and from coke-oven works; in the latter the production had increased by 14,000 tons since 1915, but there was a decrease in the producer-gas and bone and coal carbonising works, whilst the iron works and shale works had changed very little in their production. Noteworthy is the fact that 70,987 tons (included in the total) were produced as concentrated ammoniacal liquor; this branch of production was only started in 1915 and is likely to expand. The use of cheap oil (crude tar oil, &c.) for facilitating the removal of metallic sulphides in the saturator, when crude pyrites acid is used for the production of sulphide from gas liquor, is general in Scotland, but limited in England.

As regards the "direct process" of ammonium sulphate production in gas works, the difficulties to which we also referred in our account of last year's report have not yet been overcome, and the very irregular operations with respect to both gas make and the quality and quantity of the acid supplied have interfered much with the working of the process and the researches going on in two works, styled E and G in the report. The direct process was used, in 1915, in 21 works, but only 15 lb. or 20 lb. of sulphate were recovered per ton of coal instead of the expected 25 lb. or 30 lb., and the process seriously disorganised the purification plants in an anomalous way. Both the works in which the experimental research is being conducted are representative, but they differ widely as to scale of operations. The direct process dispenses with scrubbers fed with water, and replaces them by acid arresters or bubblers, in which the crude coal-gas meets with more acid than would be required to bind the ammonia. The researches of Dr. Fryer (working in conjunction with Dr. H. G. Colman) of last year indicated that the iron oxide should not contain more than 5 per cent. or 10 per cent. of moisture, that the crude gas entering the apparatus should be cool and dry, and fairly free of tar-fog, oils, naphthalene, and hydrocyanic acid; that the purifier boxes should be kept under a roof to be protected from the cold, and be worked in rotation in such a way as to bring the richest ferric hydrate in contact with the gas richest in sulphuretted hydrogen; and that the direction of flow should be downward, not upward. Unfortunately those conditions, the report points out, are far from being realised in practice. The oxide of iron delivered for immediate use often contains 50 per cent. of moisture and has to be put to use just when the gas make is at a maximum. The continued experiments—which were partly made with a model purifier, not tried before January, 1917—are described at length; they confirm, on the whole, the former conclusions, but they leave several questions open, and they hardly admit of being abstracted without entering into detail. Two points seem clear: iron hydrate approximately of the formula $Fe_2O_3 . 3H_2O$, is more efficient at high and low temperatures than the hydrate $Fe_2O_3 . 6H_2O$; and the efficiency always increases with rising temperature, at any rate for the range 41 deg. to 97 deg. F.

Nitric acid works (70, 88, 100 in 1914, 1915, 1916) did not cause much trouble in spite of increased activity; it is mentioned that further uses would have to be found for nitre-cake. There is little to be said about the 62 muriatic-acid works and the 72 tinplate-flux works; in a new process, not further described, of tinplate manufacture, the necessity of white pickling is avoided. The 92 sulphide works of 1915 rose to 96, owing to the extended manufacture of certain dyes. In arsenic works (43, against 53 in 1914), and especially in those in which arsenious acid is obtained from ores or residues or is refined, dry filters proved more efficient to stop fumes than wash towers, though both methods are satisfactory. In the 18 picric

acid works (8 in 1914) the treatment of waste fumes still leaves much to be desired; the difficulty of obtaining the necessary earthenware appliances was partly responsible for this trouble. Progress had been made in the recovery of working losses of picric acid and of the waste acid—a question of prime importance. The disastrous explosion of one picric acid works is alluded to. Tar works show a most remarkable increase, from 205 and 248 in 1914 and 1915 to 316 in 1916. This increase was almost entirely due to the extension of the use of tar dehydrating plants. In addition to continuous-distillation plants, some of which allowed the escape of obnoxious vapours at great cost to the country (loss of benzene, &c.), there are simple plants erected at moderate cost and working satisfactorily. Mr. Curphey deprecates, however, the erection of small tar-dehydration plants, sometimes of faulty design, under conditions where skilful supervision ensuring working to full advantage cannot be secured, though such works may be to the advantage of the proprietors. The tar distilled in gas works amounted to 1,420,867 tons, tar distilled in other works to 138,552 tons; the figures for pitch production were: in gas works 715,051 tons, in other works 83,690 tons.

We ought to make one addition concerning the ammonium and gas-liquor works of Scotland. There the noxious gases were destroyed in iron purifiers to the extent of 72 per cent., by combustion to the extent of 16 per cent., by the Claus process 11 per cent., and by precipitation with metallic salt 1 per cent.

NOTES.

Light and Electric Resistance.

That selenium is not the only substance whose electric resistance is diminished by exposure to light has long been known. Last year Professor A. H. Pfund, of Johns Hopkins University, found that stibnite (antimony sulphide) and cuprite (cuprous oxide) were also photosensitive. In *The Physical Review* of April, 1917, Mr. T. W. Case gives a list of more than 150 minerals which he tested as to changes of electric resistances under illumination. In most cases he obtained no evidence of any change, which does not prove, of course, that the same minerals, under different conditions of crystallisation and other circumstances, might not have, after all, appeared sensitive to light. In some cases he obtained very distinct evidence of a diminution of the electric resistance by the light. The two most noteworthy substances were acicular crystals of bismuthinite, Bi_2S_3, and a granular lead-antimony sulphide. The method of investigation he used was that he let the light of an arc lamp fall through a ring of open sectors in a rotating disc (turned by a water motor) on the crystal, which was held by an elastic clamp, pieces of platinum foil being interposed between the ends of the crystal and the springs. Lead wires were run from the crystal to an Ayrton shunt and an audion amplifier of De Forrest; the third step of this instrument was capable of increasing the energy of the original impulse by 12,000 per cent. The device was thus exceedingly sensitive. The apparatus was inserted in a 110-volt circuit. In some cases there was heating of the substance by the current passing through it; this current-heating, as well as direct heating —also tried—might of course likewise reduce the resistance. This heat-effect was gradual and slow, however, not instantaneous as with light excitation. The fatigue and recovery were also studied. Good or fair photosensitiveness was observed, in addition to the substances already mentioned, with molybdenite (MoS_2), argentite and acanthite (two silver sulphides), pearceite (Ag_9AsS_6), miargyrite ($AgSbS_2$), bournonite (sulphides of lead, copper, antimony), boulangerite ($Pb_3Sb_2S_6$), proustite (Ag_3AsS_3), pyrargyrite (Ag_3SbS_3), iodyrite (AgI), and two other silver-antimony sulphides, polybasite and stephannite. We notice the large number of sensitive silver minerals, though Mr. Case does not draw attention to this point. His two best substances, bismuthinite and the lead-antimony sulphide—he seems to mean jamesonite ($Pb_4Sb_2S_6$), though he does not say so—were more sensitive than selenium and could be used as transmitters in photophone circuits. On the other hand, crystals of the elements sulphur, tellurium, antimony and bismuth, which belong to the same group as selenium, were not found photoactive.

Chromium–Copper–Nickel Alloys.

Before the International Congress of Applied Chemistry, assembled at New York in 1912, Professor S. W. Parr described some alloys of chromium, nickel and copper, containing also a little tungsten and molybdenum, which were insoluble in nitric acid and some other acids, and which he used in particular for calorimeter construction. The high resistance to corrosion seemed, he said, largely to depend upon those minor additions. To study their influence, however, it was necessary in the first instance to investigate the ternary alloys of Cr–Cu–Ni. This has recently been done at the University of Illinois by Dr. O. E. Harder and Professor D. F. McFarland (Bulletin No. 93 of the Engineering Experiment Station of this university, 57 pages). The metals were fused together, in mixed charges of about 300 grammes, under a layer of cryolite, in Crescent safety crucibles, consisting of sand with a cover of graphite. The crucibles stood 1,600 deg. C. in a Hoskins electric furnace, but not for more than one melt, which lasted two or three hours. The chromium, of 98.99 per cent., was obtained from the Goldschmidt Thermit Company, the nickel, of 99.6 per cent., from Kahlbaum, in cubes; the copper was electrolytic, from the J. T. Baker Chemical Company, and also from Kahlbaum. Altogether 21 binary and 30 ternary alloys were prepared. Castings of Cu–Cr containing up to 13 per cent. of Cr could be poured at 1,600 deg., but they separated on slow cooling into two layers of Cr and of alloy when the Cr percentage exceeded 6.08. Equal weights of the two fused metals slowly cooled also separated into two layers, the lower rich in copper, the upper rich in chromium. Addition of nickel counteracted this separation; but it required three times as much nickel as copper to produce a homogeneous alloy. The specific gravity at 25 deg. C. of the alloys ranged from 8.92 to 7.89, decreasing with rising chromium percentage; copper and nickel have nearly the same density of 8.9 or 8.8, and chromium has the density 6.8. The Brinell hardness of the alloys varied between that of copper and of steel, increasing with increasing Cr. This increase was observed also in the case of the modulus of elasticity, ranging from 15,000,000 lb. to 40,000,000 lb. per square inch. The ultimate tensile strength ranged from 7,500 lb. up to 56,000 lb. per square inch, alloys of Cr–Ni being stronger than ternary alloys; no general conclusions as to tensile strength could be drawn from the composition. The reduction of area and the elongation were small in all cases, and the stress-deformation curves resembled those of cast-iron. The results of the tests were plotted on the triangular system, each element being at one corner of an equilateral triangle, which was divided into smaller triangles by lines parallel to the three sides corresponding to 10 per cent., 20 per cent., 30 per cent. . . . up to 90 per cent. of the respective metal. The corrosion diagrams of this type showed fairly well-defined areas of non-corrodibility, but these areas were not the same for the different reagents—acids (nitric, sulphuric, hydrochloric), sodium and ammonium hydroxide, sodium chloride, fatty acids—and the amount of corrosion was not proportional to the strength of the acid or base. On the whole, ternary alloys proved less corrodible than binary alloys, but there were exceptions, and there was no agreement between the electromotive force of the alloy in 4-normal sodium chloride solution and general corrodibility. The metallographic study suggested the existence of solid solutions of Cr–Ni and Cu–Ni; well-defined polyhedral crystals were observed in all alloys rich in Ni. In the Ni corner of the diagrams the alloys were of coarse texture and apt to develop blow-holes; that might probably be cured by addition of other metals. The high-grade Cr alloys had very high melting-points, and were too hard for machining; high-grade Cu alloys showed a tendency to segregation and were mechanically poor. The relative area of alloys which promise to be of use in the arts and are mechanically and physically satisfactory and also little corrodible, was not large, therefore.

THE RAILWAY PROBLEM.

No. III.—THE FUTURE OF BRITISH RAILWAYS.

A high official of one of the principal railways recently remarked to us that it would be exceedingly daring to prophesy as to what the future position of British railways would be. We do not propose to hazard any definite forecast, but it is desirable that the most important considerations which will influence the future of railways should be set out. This is the more necessary in view of the fact that the railway problem will be a "burning question" for some time to come. This can now be definitely asserted in view of the recent statement by the President of the Board of Trade to the Associated Society of Locomotive Engineers and Firemen, which union has been demanding an eight-hour day for engine-drivers and firemen. Speaking on behalf of the Government, Sir Albert Stanley said: "The present system of railway control would continue for some time after the war." This statement is of very wide significance. As we have shown in previous articles, in order to meet "an emergency" the control of the railways was taken over by the State on a warrant which has to be renewed from week to week (*vide* the Regulation of the Forces Act, 34 and 35 Vic. c. 86). There has hitherto been doubt whether the Government would regard the emergency as continuing for the entire period of the war. We now know that not only is this the case, but that the control will be continued for some time after the war. Whether or not an Act of Parliament will be necessary to legalise the prolongation of the control need not be discussed: on the face of it such authority would be necessary, and, if we are right in this respect, Parliament will have an opportunity of debating the railway problem.

Another matter as to which a definite opinion may be expressed is that, whatever may be the future relationship of British railways to the State and the public, there can be no return to the pre-war position of affairs. Competition between the different railway companies, which Parliament endeavoured to keep alive, has gone for ever, and with it many of the fruits of competition, such as excessively cheap excursion fares and special facilities. Of course, under any form of company ownership the traders are likely to receive the attention of the agents of the different lines, and there would be some amount of rivalry as regards the services provided, but traders will not be able to "play off" one company against another as was the case years ago. In saying this we are not unmindful of the fact that the railways had been coming together long before the war; but they have been far more together under Government control, and it is bound to have the effect which we have stated.

We are inclined to think that it may also be laid down as an axiom that, whatever the future position of the railways may be, sooner or later receipts must equal expenses, plus an adequate return for capital cost. It would appear that many advocates of State ownership overlook this important consideration. Employees and traders alike too often speak as though under a national system of railways high wages and short hours, on the one hand, and low rates and fares, on the other, would follow as a matter of course. This has merely to be stated to prove the unsoundness of such claims. The realisation of the hopes of high wages and short hours must necessarily add to the operating costs and must be equated by economies in other directions or by increased receipts. It may be that, under a State system, the burden might for a time be placed on the taxpayer, but ultimately there would be a demand for an adjustment on true economic principles. The business of the State is to weigh up the situation in the light of the wishes and opinions of all parties and decide what is the right course to take in the interest of the whole community.

Having in mind these broad principles, we can proceed to an examination of the different interests, and, in doing so, we shall somewhat vary the sequence from that adopted when reviewing the position of affairs before and during the war. Taking first the attitude of the employees, it may

be accepted as definitely established that the men and their trade unions are in favour of State ownership. At various annual and other conferences the demand for nationalisation of railways has been frequently urged, and we cannot do better than quote the resolution passed at the 1916 Trades Union Congress. It was: "That this Congress calls upon the Government to nationalise the railways completely and at the same time arrange for the trade unions concerned to have such a share in the management of the railway system as will enable railway workers to have a real voice in the control of the conditions of their life and work." The employees believe that under the State they would secure high wages and short working hours; also that their status would be somewhat higher as civil servants, and that they would have greater security of tenure than under individual companies. There would be standard conditions of service applicable alike on unremunerative lines and on important main routes. Over and above this, their trade unions desire to have a hand in the management of the lines. Little or nothing is said as to increased efficiency or economies in operating costs. Indeed, the latter would doubtless be opposed, it being part of the programme that no man should lose his position in the event of the change being made.

Now it has to be recognised that, from the point of view of the men, the advantages which were held out to them as probable under State ownership have largely materialised under State control. By various stages the whole of the operating staff have been granted concessions which now express themselves in an all-round war wage addition of 15*s.* per week. The cost of this and of corresponding adjustments in the wages of mechanics, clerks and others is understood to be not less than 25,000,000*l.* per annum. This enormous sum has been disbursed among the railway employees of Great Britain absolutely without regard to the ability of the railways to bear so large an increase of expenditure; the Government has accepted responsibility under the terms of the compensation agreement referred to on page 139 *ante*. It cannot be denied that, viewed by the men as the result of trade-union activity, the fact that so large concessions have been obtained by negotiation with the Railway Executive Committee, acting on behalf of the Government, will be regarded as proving that still larger concessions will be obtainable by similar negotiations, given the continuance of State control. Therefore railwaymen and their unions will be still more desirous than hitherto of securing the continuance of some form of national ownership or control of the railways. Let us hasten to add that we are merely stating the case as it must appeal to the men. To us it seems to be in the highest degree illogical that an advance of 15*s.* per week should be given to all employees of 18 years of age and over, regardless of their grade, rate of wages or domestic responsibility. For example, lad porters or lad engine-cleaners, who are learning railway work and are paid small commencing rates of wages—say, 15*s.* per week—receive 15*s.* war wages, or exactly the same amount as a first-class engine driver or signalman rated at 40*s.* or 48*s.* per week. Clearly an arrangement of the kind could only be defended on grounds of expediency, not logic.

Admitting that the voice of labour will be raised in favour of some form of Government ownership or control, what will be the attitude of railway directors and shareholders? This is more difficult to forecast; it will necessarily depend upon a variety of considerations. On balance, however, and for reasons which we will explain, we think that shareholders are likely to side with labour in the hope of securing their capital. According to the last available Board of Trade railway returns, the paid-up capital of the railways of the United Kingdom was 1,334,963,518*l.* The net receipts of all the railways for the year 1912 amounted to 47,329,074*l.*, or 3.55 per cent. of the paid-up capital. Interest on debentures and prior-charge stock would absorb a large proportion of the net receipts. Now we have seen that 25,000,000*l.* per annum has been added to the wages bill as war wages; there must also have been large additional expenditure due to increased prices of coal and stores. To the extent to which these factors operate after the war and are not offset by economies in operating expenditure or increased receipts, the dividend-paying powers of the railways will be temporarily impaired. We say temporarily, because we hold the opinion that, bound up as railways are with the commercial life and prosperity of the nation, it would have to be recognised that railway proprietors are entitled to a fair return on the capital they have expended. As regards wages, there is likely to be little relief, for while the anomaly represented by an all-round advance of 15*s.* must be adjusted, the adjustment will be such as materially to improve the wages of the men holding responsible posts, *e.g.*, engine drivers and signalmen, while mechanics' wages will rule higher than hitherto.

But even on the assumption that the permanent addition to rates of wages will represent a less aggregate charge than 25,000,000*l.* per annum, other factors have to be taken into account. We refer especially to hours of duty. The majority of the traffic and locomotive operating staff are now rated at 10 hours per day, or 60 per week, and for years the trade unions have put forward a demand for an eight-hour day. The drivers and allied grades of locomotive men have recently been so insistent on this that they have gone to the length of threatening a strike to secure it. It was in connection with this threat that the Government intimated that the present system of railway control would continue for some time after the war. Sir Albert Stanley added to this the significant comment that "there would be an opportunity of raising and dealing with the question of hours on the conclusion of peace." A hint of this nature will be regarded by the men as a promise that hours will be reduced. Reliable authorities have estimated that the concession of an eight-hour day or 48-hour week to railwaymen would cost at least 8,000,000*l.* per annum. This would more than counterbalance any saving likely to be effected when the war wages are withdrawn and permanent conditions of service are settled after the war. Moreover, economies are unlikely to be effected by reduction of staff, seeing that over 150,000 railwaymen have joined the colours with a promise of reinstatement on discharge from the Army. If only half of these men return to the railways the effect on the wages bill is obvious. Not only so, but it must be assumed that additional staff will be needed. Maintenance of permanent way and works has fallen behind and will have to be overtaken when normal conditions are resumed. So far as can be provided for on pre-war figures, financial provision is now being made by the railways, but at best this money will merely serve to restore the lines to their former standard and will not assist the railways to meet permanent additional expenditure in respect of higher rates of wages and reduced hours of the staff.

There remains the question of effecting economies in other directions. This is a much more hopeful source of assistance. In our view much can be done by continued cessation of wasteful competition; by revising and co-ordinating the services between places served by two or more railways, and especially in regard to collection and delivery and terminal accommodation in large towns, and by further increasing the weight of trains and eliminating empty haulage of vehicles. Labour-saving devices at stations are only now beginning to be introduced, and the enhanced cost of labour will be a potent factor in hastening their installation. What can be done has been shown by the Lancashire and Yorkshire Railway, *vide* ENGINEERING of February 23 last. It may also be taken for granted that during the period of Government control the railways have discovered that office staffs can be greatly curtailed. The Railway Clearing House staff has been materially cut down, and in a variety of ways the railways have revised their methods of conducting office work. By stamping parcels traffic instead of waybilling clerkage has been reduced, and by pooling arrangements instead of elaborate divisions of receipts there will be similar results. Labour-saving appliances will also be used in offices to an increasing extent. It is difficult to estimate the effect of these developments upon railway expenditure, but there can be no doubt that it will be very considerable.

We think, however, that the increased expenditure which we have foreshadowed is unlikely to be wholly offset by economies in operating and maintenance costs. Therefore, from the point of view of railway shareholders and directors, the continuance of some form of State guarantee has obvious attractions. For the first time in railway history a new basis of compensating the companies has been discovered. Hitherto the only official basis on which the State has contemplated nationalisation of the railways has been that set out in the Act of 1844 (7 and 8 Vic. c. 85). This was that any railways constructed after that year should be purchasable for a sum equal to 25 years' purchase of the average annual divisible profits for three years before such purchase, provided the profits equal or exceed 10 per cent. on the capital; if not, the railways should be at liberty to claim any further sum for anticipated profits, to be fixed by arbitration. These powers have never been exercised; indeed, when the matter was seriously discussed by the Royal Commission on Railways of 1867 the recommendation was as follows: "We are of opinion that it is inexpedient at present to subvert the policy which has hitherto been adopted of leaving the construction and management of railways to the free enterprise of the people, under such conditions as Parliament may think fit to impose for the general welfare of the public." We think that this opinion would be endorsed by all disinterested persons at the present time. We are, however, attempting to estimate the views of railway proprietors, and we cannot avoid the conclusion that they would favour the maintenance of what they are now enjoying. This is the guarantee of the net receipts for the year which, as has been shown (ENGINEERING of August 3, page 127), was the best they had ever experienced. While not a guarantee of dividends, it must be obvious that its effect is practically the same as a guaranteed dividend. Now the Government have intimated that the present control is to continue during the war and for some time afterwards. That being so, and if we are correct as to the probable upward trend of expenditure, is it not in the highest degree probable that railway directors and shareholders will strive to perpetuate some arrangement of the kind, short of disposing of their property to the State on equally advantageous terms?

Next let us consider the point of view of the trader. In the past there have been complaints of high rates, and nationalisation has been favoured in the hope of securing their reduction. There has also been a desire to establish advisory committees, representative of chambers of commerce and railway companies, for the purpose of discussing rates, complaints, facilities, &c. Even since the war this has been proposed by a sub-committee of the Advisory Committee to the Board of Trade on Commercial Intelligence with respect to measures for securing the position, after the war, of British industry. That body has proposed that "an impartial tribunal should be set up to secure that no preference is accorded to traders in other countries by . . . home railways; that is, that rates charged by . . . railways to British traders shall in no case be higher under similar conditions than those charged to traders operating from another country, the principle adopted being that equality of payment entitles traders to equality of service." Advisory committees might be established with equal or greater effect under company ownership as under a national system of railways. Therefore the principal question is whether nationalisation would be so productive of economies as to result in cheapening of transit charges. We do not propose to enter into any elaborate comparisons of British and foreign rates. In our view the requisite data are not available to enable any reliable opinion to be formed, for the reason that it is not the practice in this country to compile ton-mileage statistics, while British railway rates include services not provided in other countries, such as collection and delivery. Then the system of special rates so prevalent here is another disturbing factor, while the short haulage in this country and retail character of the business methods also render any comparisons a matter of difficulty. According to the conclusion desired to be

established it is possible to quote rates for particular traffics and comparable distances in this country compared with Germany or France to show that British railway rates are higher or lower than those with which comparison is instituted. We are, however, quite prepared to accept the view that British rates are higher than those of many foreign countries. The point we desire to establish is that, taking all things into consideration, there is no probability of the rates being reduced. What the traders have to decide is whether their interests are likely to be best served by State railways—with State bureaucratic methods, coupled with lack of initiative and enterprise, and possibly of Parliamentary influences—as they are by company-operated lines, notwithstanding that the companies will continue to combine and co-operate according to the pre-war tendency in that respect, and that rates may have to be increased to balance growth of expenditure. We feel that the experience of State control of railways during and after the war will cause the majority of the trading and travelling public to oppose nationalisation of railways.

Sufficient has been said to show that the railway problem will require the most careful consideration by the Government and that it will be by no means easy of solution. By the time the control in its present form is due to be raised it may well be that the railways will not be in a position to pay a dividend on their ordinary stock. If such were the case, the Government could not withdraw the present guarantee without agreeing to an advance of rates and charges, more especially in view of the good services which, as generally admitted, the railways have rendered during the war. It is possible, however, that the position will be complicated by another matter which must affect the ultimate decision, viz., the necessity for obtaining capital. Expenditure on capital account will be necessary in order to provide for growth of traffic, and especially for rearranging and modernising terminal accommodation, more particularly goods depots, to enable labour-saving machinery to be fully used. We are not sanguine that capital will be forthcoming through the usual channels; indeed, many of the large companies' accounts show that there is already an overdraft in the capital expenditure figures. It may be, therefore, that the State will find itself faced with the necessity of providing capital for the railways after the war and during the period for which the present control continues. Should this be the case it must necessarily influence the final decision as to the future relation of railways to the State.

As was shown in the first article of this series, there is already much material in existence awaiting executive action. There are outstanding recommendations by the Board of Trade Conference of 1908, and the proposals embodied in the Railways Bill of 1912. Further, as a guide to what will be necessary if company ownership continues, there are the recommendations of the Departmental Committee of 1911 on Railway Agreements and Amalgamations. That committee's most important conclusions were: "First, that the natural lines of the development of an improved and more economical railway system lie in the direction of more perfect co-operation between the various railway companies; and that we accept the growth of co-operation and the more complete elimination of competition as a process at once inevitable and likely to be beneficial both to the railway companies themselves, and, if properly safeguarded, to the public also. Second, that the protection required by the public cannot be afforded by any system of sanctioning or regulating agreements, but that such protection must in the main be given by general legislation dealing with any injurious consequences of the co-operative action of particular railways, or the assimilation of railway practice, independently of whether they occur as the results of formal agreements or not."

To summarise our conclusions: We take the view that railway shareholders and employees will favour railway nationalisation or State financial control and guarantees. On the other hand, traders and the travelling public will probably come to the conclusion that State management would be less efficient than private ownership, while Government patronage and political influences would be likely still further to prejudice their interests. What is most essential is that no decision should be come to without the fullest consideration of the railway problem in all its bearings and free public discussion. Fortunately there exists the machinery for the usual commencement, viz., the Royal Commission on Railways, whose sittings have been suspended during the war. The terms of reference admirably meet the case. They are "To inquire into the relationship between the railway companies of Great Britain and the State in respect of matters other than safety of working and conditions of employment, and to report what changes, if any, are desirable in that relationship." The inquiry of the Commission should be recommenced immediately on the conclusion of peace; it should be of the most complete and far-reaching character, and the recommendations of the Commission should be the basis for prompt decision as to the course to be taken by the Government. Pending that decision the present form of State control will doubtless be continued.

LITERATURE.

Centrifugal Pumps. By R. L. Daugherty. New York: McGraw-Hill Book Company. [Price 8s. 4d. net.]

Centrifugal Pumps and Suction Dredgers. By E. W. Sargeant. London: Charles Griffin and Co., Limited. [Price 10s. 6d. net.]

During the past few years the centrifugal pump has received considerable attention from the practical and the scientific point of view. There is an undeniable attraction and interest centred around this little machine; it is so charmingly simple and is very successful in practical operation, also it is simple in its elementary calculation, and not difficult in its complete mathematical treatment. However, if one tries to reconcile its mathematics with its actual behaviour throughout the whole range of its possible operation, and if one attempts to pursue or forecast the effects of modifications in the apparently trifling features of its design, one is met by a baffling labyrinth of intricacies through which none but experienced practical designers can thread a certain way. As a matter of fact, the commercial centrifugal pump is a well-understood and firmly-established reality and special experience is only required when one attempts to design a single pump for a variety of duties, or when one commences the search for the extra 1 per cent. in efficiency with which it is hoped to achieve an economy, and possibly to secure increased business.

The two books before us treat of their subject from different points of view. With his long specialised experience Mr. Sargeant is able to indicate what is sound practice in many directions, and he often mentions constructive and manufacturing points that would be passed over by anyone not so well versed in the subject. His book provides a valuable discussion of the practical and commercial side of centrifugal pump manufacture, and supplies a very simple basis for a "drawing office" method of design. The several parts of a centrifugal pump, the different forms these parts assume for different conditions, and the methods best adapted for their manufacture are all considered; foundry moulding, being a most important item in economical pump manufacture, receives special treatment. The subjects of priming, testing, arranging and installing centrifugal pumps are fully treated, and much attention is given to salvage plant, dredging and "solids" pumps. The book supplies a general sketch of the whole field claimed by the centrifugal pump, the author stating in a decisive and convincing manner what he has learnt from first-hand personal experience during a practice of some thirty years.

Mr. Sargeant does not pretend to enter into the theoretical or mathematical side of design, nor to give any derivation of the various coefficients advised; he reduces velocities throughout the pump to factors of the term

$$\sqrt{2.g.H}$$

and simply says if one uses certain blade angles and proportions, all of which are known to be good and to be applicable to certain cases, then the value of the factors must be so and so for good results.

Mr. Daugherty, on the other hand, does not recommend any particular practice at all, and is clearly at his best when concerned with the mathematical analysis of the subject. He attempts to reduce the complicated phenomena of pump behaviour and variation in "characteristics" to an intelligible theory; subsequently developing this theory into a practical method of design requiring a number of factors and the known or intended dimensions of the pump. In a sense the two works are complementary to each other, the one supplying the deficiency of the other.

Looking at Mr. Sargeant's book we find in the second chapter a very appealing illustration of why the peripheral velocity of a pump impeller should approximate to the final velocity

$$v = \sqrt{2.g.H}$$

of a body which has fallen, under the influence of gravity, from a height equal to the head against which the pump is intended to deliver. The first obvious "coefficient" is the well-known one which expresses the relation of the peripheral velocity to this gravitational velocity; after that it is a simple matter to express all water velocities in terms of the same gravitational velocity and so obtain other coefficients. In considering relationships to

$$\sqrt{2.g.H}$$

it is essential to remember that the head "H" is a variable throughout the pump behaviour at any given peripheral speed, and it is therefore only possible to use designing factors of the class mentioned with safety when designing for operation at normal output. Mr. Sargeant gives recommendations for the values of the coefficients he selects, and works out illustrations utilising the factors given. In connection with this it is rather disappointing to be told that certain impeller vane angles "are quite suitable," also that certain combinations of angles "would be suitable" to certain other work, without being told exactly why, or without any hint as to how the coefficients should be varied if one chose to depart from the suggested data.

A noteworthy recommendation in the early portion of the book is the advice to design for a volute velocity of about

$$0.35\ \sqrt{2.g.H}$$

for practically all volute casings. Mr. Sargeant says that "maximum efficiency" will always occur when the volute velocities lie between the limits

$$0.3 \text{ and } 0.45\ \sqrt{2.g.H.}$$

and on page 11 he says "will . . . nearly always occur when the volute speed is about

$$0.35\ \sqrt{2.g.H.}"$$

There is a rational basis for this coefficient, though the author does not say so. Using well-known methods for the best conditions of flow in a centrifugal pump, it is easy to show that when vane angles and other pump proportions are taken into account over a wide range of tip angles (from, say, 15 deg. to 90 deg.), peripheral areas and volute areas, the values of the coefficient have a range between

$$0.1 \text{ and } 0.5\ \sqrt{2.g.H.}$$

cases being found in practice for all values between these numerical limits. For the more common tip angles of 30 deg. to 40 deg. recommended by Mr. Sargeant, it is easily seen that the coefficient must be from 0.3 to about 0.43 for the average proportions of volute and impeller. While on this subject it is interesting to read in Mr. Daugherty's book (page 67) that "it is now thought to be better to make the volute smaller," so that the velocity at this portion is greater than would be given by the above relation. A statement like this requires some qualification. Maximum efficiency can only be arranged at higher velocities than the above by the introduction of guide vanes or a volute which in form practically amounts to a single guide vane. Unfortunately it is not possible to arrange hydraulic losses on paper, they take place as a direct result of passage-form and velocity-change. Transmission of the energy contained in a liquid during and immediately after its passage from a

rapidly moving member, to a stationary member, is an exceedingly delicate practical operation. As a matter of fact, if stream-line flow is disturbed in any way the maximum efficiency of the transmission will occur when the final velocity is about half the initial velocity, but if stream-line flow can be approximately preserved the transfer of liquid may take place at higher velocities and thus leave greater scope for conversion into potential energy after the transmission. Designers will know that perfect stream-line flow in a transference of the kind in question is a dream that they are constantly trying to materialise.

The principal factors derived by Mr. Daugherty relate to the same features in design as the factors of Mr. Sargeant, viz., to the peripheral velocity, the flow in the impeller and the flow in the volute. Neither of the writers, however, emphasises the extreme importance and dominating influence on the pump behaviour of the ratio between the last two "flows" mentioned. Mr. Daugherty lays stress upon the impeller design, while Mr. Sargeant apparently attaches faith to the volute area; whereas it is an indisputable fact that the point of maximum efficiency of a pump is governed by the "ratio" between the two. A point to be guarded against is that the method of coefficients advocated by both authors might possibly lead one to the erroneous view that the point of maximum efficiency of a pump is determined by the relationship between certain water or impeller velocities and the gravitational velocity.

The subject of "pitting" of vane-tips is a most interesting one and is touched on by both writers. Mr. Sargeant (page 55) favours electrolytic action, but in this we think he is against the general opinion, which maintains that tip conditions are unfavourable to the circuit currents necessary in electrolysis. Mr. Daugherty (pages 41 and 42) evidently believes in eddies containing cores of liberated oxygen which destroy the metal. Experience seems to strengthen the latter view, as vane-tip corrosion has been sensibly reduced by diminishing the facilities for freeing of dissolved air and by improvements in hydraulic design which eliminate the conditions tending to "eddy" or "whirl" formation.

A welcome feature of Mr. Sargeant's book is the large amount of information given on pumps for dealing with solids in suspension in water; we certainly do not remember seeing this subject so well treated before; quite a large amount of practical detail is given.

With regard to prominent questions now exercising the minds of manufacturers and designers, such as the accurate forecasting of the complete shape of a pump characteristic, the increase of turbine or guide-vane pump efficiency by the introduction of all-round refinements, and the improvement, both mechanically and hydraulically, of appliances for counteracting axial thrust in high-pressure pumps, readers will be disappointed to find that the subjects are either unmentioned or simply receive a passing reference.

BOOKS RECEIVED.

Annual Report of the Minister of Mines for the Year Ending 31st December, 1916, being an Account of Mining Operations for Gold, Coal, &c., in the Province of British Columbia. Victoria, B.C.: William H. Cullin.

Les Etablissements d'Artillerie Belges pendant la Guerre. Par COMMANDANT WILLY BRETON. Préface de EMILE VANDERVELDE. Paris: Berger-Leorault. [Price 6 francs.]

Watt and the Steam Age. By JOHN W. GRANT, C.E. London: St. Bride's Press, Limited. [Price 7s. 6d. net.]

Bulletin of the Imperial Institute: A Quarterly Record of Progress in Tropical Agriculture and Industries and the Commercial Utilisation of the Natural Resources of the Dominions, Colonies and India. Vol. XV, No. 1, January–March, 1917. London: John Murray. [Post free 2s. 9d.]

United States Bureau of Mines. Technical Papers. No. 132. *Underground Latrines for Mines.* By JOSEPH H. WHITE. [Price 10 cents.] No. 142. *Vapour Pressures of Various Compounds at Low Temperatures.* By G. A. BURRELL and I. W. ROBERTSON. [Price 5 cents.] No. 146. *The Nitration of Toluene.* By E. J. HOFFMAN. [Price 5 cents.] Washington: Government Printing Office.

The Universal Directory of Railway Officials, 1917. Compiled from Official Sources under the direction of S. R. BLUNDSTONE. London: The Directory Publishing Company, Limited. [Price 15s.]

CORROSION OF CONDENSER TUBES.

TO THE EDITOR OF ENGINEERING.

SIR,—Might I suggest that Mr. Elliott Cumberland could narrow the issue very materially if he would eliminate from his list of corrosion causes the chemical and mechanical, and for these substitute the mythical. Surely with our present knowledge of science it is unnecessary to discuss such dead and damned ideas as chemical or mechanical corrosion. The very basis of the Cumberland process depends on the cause being electrolytic. If it were, as "C. de F.M." assumes, mechanical, this system would have no more effect than it would have on a file or drill cutting the metal; and if, on the other hand, the solution of the metal were purely chemical, he would have to supply an electromotive force sufficiently great to redeposit the dissolved metal if his process had to work. Mr. Cumberland creates an artificial back E.M.F. just sufficient to polarise the surfaces to be protected. It is a sound principle, and capable of further development. I remember it being tried in a steamship's boilers some twenty-five years ago with apparent success — apparent, because when the apparatus was discarded the boilers still remained in good condition after long service.

By no means let the poor patient die. A sound diagnosis will surely indicate the cure, but simple guessing supported by shaky figures affords the subject a poor prospect of recovery.

In condenser tubes, as with humanity, we are more concerned about the high infantile mortality than about the diseases of old age.

The galvanic theory of corrosion is well supported by facts, observed and experimental, while other theories will not bear scientific examination. Much of the confusion arises from a wrong conception of the nature of oxidation or corrosion by air at ordinary temperatures. Such oxidation can only take place when the air becomes part of an electrolyte; the increase in E.M.F. due to solution of air in a cell can easily be demonstrated, and no stretch of magination can distort such increase into anything but electrolysis.

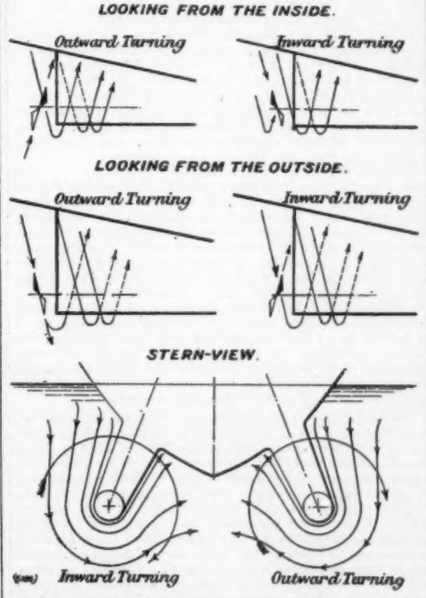
Yours faithfully,
WM. RAMSAY.

23, Sycamore-road, Higher Tranmere, Birkenhead,
August 21, 1917.

"ON THE DIFFERENCE IN EFFECT OF TWIN SCREWS WHEN TURNING 'INWARD' OR 'OUTWARD.'"

TO THE EDITOR OF ENGINEERING.

SIR,—With great interest I took notice of the letter by Mr. Knudsen which appeared in your issue of July 20 last, page 60, on the results obtained on the trials of the twin-screw railway ferry, Christian IX. It appears from these trials that a superior effect has been obtained by making the screws of this ship turn inward instead of turning outward, and this statement, as it is accompanied by sufficient data to allow of some nearer investigation, is to be considered as very valuable, affording as it does some more data which may throw a light on this interesting subject.



The observation made by Mr. Knudsen, that at all speeds a constant gain of nearly 0.8 knots has been observed, seemed to indicate that in this case a constant value has been added to the slip value of the inward-turning propellers, and that this same constant value has diminished the slip value of the outward-turning ones. If so this value cannot depend upon the speed of the ship, varying between 7.50 knots and 14.50 knots, but must depend on some other velocity of the water in the immediate vicinity of the propellers.

Further, the value of this constant must be important enough to overcome the loss caused by the negative slip, which is stated at the speed of 7.50 knots for the inward-turning condition, and yet to produce sufficient pressure to drive the ship at the stated speed.

Lastly, the direction of this flow of water, causing the constant pressure in excess of that caused by the slip, must be parallel to the slip angle when turning outward, and opposite to it when turning inward. Only under such conditions will the causes to which gain or loss were attributed, in the cases dealt with in my article referred to by Mr. Knudsen, be able to cause gain or loss in the case of the ship now under consideration.

The same calculations as used to examine the examples of the yacht Niagara and the mail steamer Rotterdam gave me as results that there is to be expected a flow of water having a velocity of 6 ft. 4 in. per second to account for the differences in speed observed, and to turn the effect of the negative slip into a positive pressure amounting to 1.880 tons per screw, at the speed of 7.50 knots (turning inward), and giving 1.520 tons per screw at the speed of nearly 6.7 knots, when turning outward.

This flow of water at a constant velocity, independent of the speed of the ship, is, in my opinion, a flow filling up the space behind the bosses, flowing in a direction as shown on the accompanying diagrams, parallel with the direction of turning outward, and opposed to it when turning inward, and thereby producing the gains and losses stated on the trials. It would certainly be of great interest if more analogous cases should be made known, so that they might be investigated in the same manner. Thanking you for the space put at my disposal,

I remain, dear sir, yours truly,
C. H. HOLST.

Overveen, August 14, 1917, Zijlweg 110.

WAR TIME PATENTS.

TO THE EDITOR OF ENGINEERING.

SIR,—In normal times the provisions of the International Patents Convention, which afford inventors protection for twelve months wherein they may apply for letters abroad, have proved beneficent in their operations, but their rigid application during the currency of the present war is calculated to work hardship, and inflict loss upon the class they were designed to assist. Perhaps no form of business is so susceptible of confusion during this world-wide war as that concerning patent applications and the observance of the rules laid down by foreign countries in that behalf. Agents may forward their documents to their associates in ample time for lodgment, and months afterwards learn that for State reasons the fact that the ship that carried the papers was sunk was concealed. It is then too late to remedy the mischief. In my own case a letter of inquiry to my agent in Europe also failed to reach its destination. An English inventor, in such circumstances, may be able to forward substitute documents within the prescribed time, but what resource is open to a resident of Cape Colony who fails to file his application in the United States Patent Office within nine months from the date of his provisional protection?

Under the provisions of the Convention time is the essence of the contract, but no court of law would hold a party debarred from establishing his rights because the force of an enemy prevented strict compliance with one of its rules. Unless some agreement is come to by the Governments subscribing to the Convention whereby patent applications interrupted by the state of war may proceed within a reasonable time from the signing of the protocol of peace, I and a good many other inventors will be excluded by the present hard-and-fast rule. In this emergency, as in every other affecting science and applied mechanics, professional men and inventors living on the outer marches of the Empire look with confidence to the great institutes of the Motherland to exercise their influence to see that when the great clearing-up occurs, patent disabilities arising from the present unprecedented war conditions, are not forgotten.

Yours faithfully,
June 6, 1917. "LOCUS PŒNITENTIÆ."

CAPE TO CAIRO RAILWAY.—A special despatch from Elizabethville to *The African World* announces the completion, in connection with the Cape to Cairo Railway, of the railroad to Bukama on the navigable Congo. The line now covers a distance of 2,700 miles direct from Cape Town via Rhodesia.

"THE UNIVERSAL DIRECTORY OF RAILWAY OFFICIALS, 1917."—This valuable volume appears for the twenty-third time. It has suffered from the effects of the war. The sections relating to the railways of Austria, Belgium, Bulgaria, Germany, Hungary, Serbia and Turkey have necessarily been omitted. For the same reason the sections relating to the railways in certain parts of France and Russia have not been corrected. On the other hand all tramways worked by power are included. Subject to the above exceptions, all the railways of the world are dealt with. The extent of the particulars differs somewhat, but generally there is included the name, length, gauge, number of locomotives, tenders, carriages, wagons, horses, road vehicles, names of chairman, deputy chairman, directors, auditors, secretary and the principal legal, commercial and clerical officials, engineers (including district engineers), and some other officials. Finally, there is an index of railway officials. The volume is issued by the Directory Publishing Company, Limited, of 15, Farringdon-avenue, E.C. 4, at the price of 15s.

TURBO-ELECTRIC PROPELLING MACHINERY IN UNITED STATES BATTLE-CRUISERS.

In our issue of December 22, 1916, we reprinted a paper on "Alquist Gearing for Ship Propulsion," read by Mr. W. L. R. Emmett before the American Society of Naval Architects and Marine Engineers in New York. The discussion on this paper has now come to hand, and in the discussion particulars were asked as to the reasons why the American Navy had adopted the electric drive for some of their latest battleships instead of the turbine drive. In his reply Mr. Emmett gave the following explanation, which forms part of an article he has recently written upon the subject.

The writer has for many years actively advocated electric drive for the larger vessels of the United States Navy, and as a result of a long campaign of designing, experimenting and educational activity this method has been adopted on a large scale by the United States Navy Department. Electric propelling machinery has been ordered for the last seven battleships which have been authorised, and is specified for the four new battle cruisers which form part of the present naval programme. These battleships are very large and important vessels, requiring 33,000 h.p. each, and the battle cruisers involve the most stupendous propulsion problem ever presented, since they require no less than 180,000 h.p. each. Only two or three of our cities use as much electricity as will be generated on one of these ships when she makes her full speed of 35 knots.

Electric propulsion has from the first had many opponents, and it is still being very actively opposed by nearly all the shipbuilders of the country, by Sir Charles Parsons, Mr. Charles Curtis, and others who have had important influence in marine engineering. Most of this opposition is undoubtedly sincere, but is not altogether disinterested, since shipbuilders want to use machinery which they know how to build, and since turbine inventors have in the past received large royalties from turbine-driven ships, which are cut off by the advent of electric drive. Although the power still comes from turbines, the electric drive is, by licence agreements, free from royalty charges. The possibilities of large electrical apparatus do not appeal strongly to those who are not thoroughly familiar with its uses. Electric propelling machinery will be generally heavier and more expensive than the best developments of geared turbine machinery, and variations of opinion have rested upon the relative importance given to advantages and disadvantages.

The General Electric Company (of New York) has, under the writer's direction, also carried on extensive developments and operations in ship propulsion by turbines connected to ships' propellers by gearing. Machinery of this class for 79 large vessels has been contracted for by them, and many of these ships are in service and showing unqualified success. Our view, therefore, is not entirely one-sided, and although it may be considered that we are particularly interested in the development of the uses of electrical machinery, we believe that we have judged fairly and that our efforts will lead to important and lasting success.

In explaining the advantages of electric drive, comparisons will be made only with the geared turbine drive. All other methods for propelling large vessels may be considered obsolete, although many ships are still being built with engines or with direct-connected turbines.

A wise rule in engineering is to advocate new things only for the purpose in which they afford the greatest advantages, and this rule has been closely followed in the promotion of electric propulsion, which was originally advocated mainly for large warships. This first move was made before the use of mechanical gearing for such a purpose had been suggested, but its advantages for this particular use are so striking that it is still believed that the wonderful development of gearing possibilities have not changed the original case.

The subject of electric drive is too large for full discussion in such an article as this. Its possibilities and advantages can be best suggested by taking as an example the case of the new United States battle cruisers, in which its use has been and still is the subject of much discussion and criticism. This may be considered as the extreme case, where advantages are most important and in which the disadvantage of increased weight is most serious.

New Battle Cruisers.—Four of these vessels are authorised in the Navy Bill of 1916. They are designed to make 35 knots each, requiring 180,000 h.p. delivered to four shafts turning at full speed about 250 r.p.m. These are the fastest and most highly-powered vessels ever built. The electrical installation proposed in each of them far exceeds in extent any single installation ever made for any purpose.

Apparatus Proposed.—It is proposed to instal in these ships four high-speed turbine-driven generating units of the best type, similar in most respects to those used in power stations on shore. Upon each of the four propeller shafts will be mounted two independent induction motors. Cable connections and switching arrangements will be provided by which any combination of motors and generators can be immediately provided for and by which all the changes of connections for operation, reversal, &c., can be instantly made under all running conditions. The details of design and method of operation need not be described in this discussion. They are quite simple, in fact much simpler than in most electrical installations. The electric supply is produced for the one purpose of propulsion, and is varied or discontinued according to need. Connections are changed only on dead circuit, even in the ordinary operations of stopping, starting and reversing, and automatic means are provided by which any diversion of current from any cause produces an unbalancing which instantly breaks the field circuit and de-energises the system.

The aggregate weight of this equipment, with cables, switches, instruments and controlling apparatus, is 1,865 tons.

Equipment if Gear-driven.—If such a vessel were gear-driven, a plurality of ahead turbines would be connected through helical gearing to each propeller shaft. One or more backing turbines would also be connected through the same gearing, and if good cruising economy were sought, it would be necessary to provide also cruising turbines, connected through separate means of gearing and arranged with couplings so that they could be detached during high-speed operation.

A just comparison of this method with the electric equipment proposed would require a complete design and analytical study of the geared equipment and its performances. The writer has not made such a study in the case of these vessels, therefore no exact figures can be given. The space and number of turbine elements connected to each shaft will determine the space required for turbines, and this spacing will govern the length and weight of the shafts, piping, valves and supporting structures.

In some of the installations which have been proposed abroad for vessels of much less power than these the multiplication of parts has been very great and the size and extent of turbines and supporting structures such that the adoption of similar methods in these ships would certainly give weights nearly as great as, if not greater than, those proposed for the electric drive. Some of our shipbuilders, in bidding to the Government on these vessels, have stated that by using geared equipment they could save about 1,000 tons in weight and about 1,000,000 dols. in cost, but whether these statements will bear analysis or not cannot be said without study of their detailed designs, if any have been made.

Detachment.—Without further description or discussion of either type of apparatus, we are in a position to make a comparison which constitutes one of the most important advantages of electric drive. In the geared equipment each shaft has a system of turbines, gears, bearings, thrust-balancing devices, and lubricating systems, all mechanically locked together. With high-speed machinery any kind of trouble with any of these parts will almost certainly necessitate the immediate stoppage of the whole system. To keep a high-speed turbine running out of balance or with bearing trouble is impossible, and the gearing part would present almost equal difficulty. In the event of mechanical trouble of such character, a ship would have to be stopped until the wreck could be cleared. The work necessary to uncouple and disconnect any part of such very heavy apparatus would be a serious matter, involving much time, including that required to stop the ship. After the disconnection was made the idle propeller would act as a very serious drag on a fast vessel.

In the electrically-driven ship there is no mechanical connection of the shaft to anything but the rotors of motors. These are self-contained ironclad structures and cannot by any possibility be subject to mechanical interference. The shafts are subject to the same possibilities of bearing or thrust trouble as shafts in other ships, but the presence of the motors does not increase this danger, and the speed being low it is remote in any case. With this equipment any motor, generator or turbine, if in any kind of trouble, can be instantly disconnected without stopping the ship, and with only a small loss from the highest speed capacity.

Interchangeability.—Such interchangeability as this power of disconnection gives constitutes one of the most important advantages of electric drive in such a ship. With one motor out of eight in trouble, only one-eighth of the maximum capacity is lost, and the ship's maximum speed is impaired by only about 1 knot. If a generator or turbine is in trouble, the maximum speed is reduced only about 2 knots. With two generating units and four motors out the ship can make 26 knots, and with three generators and four motors out she can make 19 knots. If parts give trouble they are simply cut out and repaired at leisure or as opportunity affords. The value of this interchangeability in a warship can hardly be overestimated; it largely overcomes the military danger incident to accidents to the driving power, a danger which has always been of primary importance.

Backing Power.—In turbine-driven ships, not electric, it is necessary to provide backing turbines, which must run idle in the reverse direction when the ship is going ahead. These backing turbines involve complications which are very objectionable, and if these are reduced to a desirable minimum the backing power will be greatly inferior to that easily provided with electric drive. Experiment has shown that a turbine forced in an opposite direction involves about seven times as much friction loss as when driven in its normal direction. This loss is very appreciable in the backing turbines of ships and causes heating, which must be dissipated by circulating steam, which causes further loss and waste. There are also serious difficulties and dangers in high-speed apparatus incident to the abrupt and wide changes of temperature where steam is suddenly admitted to a cold reversing turbine. Steam which expands without doing work has a high temperature, and if work is done upon it by a reversed turbine the heat is considerably increased. With superheat these temperatures may be extreme, and they affect the main turbine as well as the other, since it also must be used for reversal of direction and since the two often occupy the same casing. The mechanical effect of such abrupt change of steam temperature upon fragile structures presenting very extended surfaces is a matter which has been little considered, but which has caused much serious trouble. With electric drive the turbine never need be stopped when the ship is under way, and its operation is easier than in a power station because the load is steadier. With modern high-speed turbines superheat affords large gains in fuel economy, and the ability safely to use high degrees of superheat may constitute one of the important reasons for adopting electric drive.

Efficiency of Transmission.—Various statements and estimates have been published concerning losses in high-speed gearing for which the authority is not known by the writer. Tests at Schenectady have shown losses about double those generally estimated, with rapid diminution of efficiency as load falls. These tests were of a most accurate character, with large smooth-running gears and by the motor-generator method, where losses alone were measured, the same power being transmitted with and without the gearing.

With the electric drive in these battle cruisers, the losses from turbine to propeller shaft at full speed will amount to 7 per cent., and by adjustment of voltage the transmission efficiency can be kept equally good at all speeds. Considering gearing losses, reversing turbine losses, losses incident to necessary subdivisions of the turbine and additional packings, it is believed that the actual transmission from turbine blades to shaft at full speed cannot be made more than 2 per cent. better in the geared equipment than it is in the electric. At reduced loads the geared equipment will be much less efficient. The normal cruising speed of these ships will require less than one-tenth of full load, and the drag of gearing, bearings, reversing turbines and idle parts of main turbines will be very serious. Some of these matters seem to have been ignored in statements which have recently been made on the subject.

Cruising Economy.—With the electric design the number of motors and turbines used can be adapted to the demand for power, while with the other all parts must be kept running. This gives very important gain in economy at all speeds below the maximum. At 19 knots only one turbine is required to drive the ship, and electrical arrangements are made by which it can be run at full speed instead of running at half speed, as it would if the ratio were fixed as by gearing. Thus the steam efficiency at 19 knots, a desirable cruising speed, is equal to the best attainable at any speed. Assertions which have been made by shipbuilders and others that equal cruising results can be obtained by the use of cruising turbines are obviously absurd. The cruising turbines themselves would be greatly inferior to the single main turbine so used, and they would be burdened with all the drags which are mentioned above. Cruising economy gives increased cruising radius without renewal of fuel supply. This has always been considered a matter of the greatest importance in warships; it is a feature in respect of which electric drive can have no rival.

State of Development and Expediency.—Enough has been said to give an idea of the reasons for the use of electricity in such ships, but in addition it should be considered that everything used in such an electric installation is a matter of exact knowledge and wide experience, while methods of gearing on such a scale are backed by little and brief experience and are the subject of wide difference of opinion as to methods of design and proportions.

The writer believes that the differences of weight and cost which have been predicted by shipbuilders and others are not based upon just comparisons, but even if they are true they are not sufficient to balance the practical merits of electric drive for such vessels.

For these reasons it is believed that when prejudices are overcome electricity will develop an extensive use in large high-power warships. In such light vessels as scouts and destroyers, for reasons of weight and space, it is relatively much less desirable, but even in such cases, with the lightest and most compact designs, and with very high pressure and superheat, it might in the future develop a legitimate application. In merchant ships also it may afford great advantages. With electricity turbine units can be installed in duplicate, either in single or twin-screw ships. Machinery can be installed where convenient, with motors near propellers and turbines near boilers; auxiliaries can be driven electrically from the main units. The highest superheat can be used without danger or complication, and main units can be applied to other power uses such as cargo pumping and handling. These advantages have led to the preference of electric drive at a higher price in certain large freighters recently ordered, and will doubtless lead to many other applications in ships of various types.

Cobalt in Thermocouples.—Among the advantages claimed for cobalt, notably by the advocates of a cobalt industry in Canada, is that cobalt wires or rods remain ductile and malleable with continued use in thermocouples when nickel wires turn brittle. This claim is supported by Dr. O. L. Kowalke, of the University of Wisconsin, who had made up a thermocouple out of nichrome and a rod of cobalt, 0.5 cm. square, forged from an ingot: this couple had been in use in hot gases and fused electrolytes for several years, and was still serviceable. (Transactions American Electrochemical Society, vol. 29, pp. 561 to 568.) The good result induced him to test various thermocouples in which cobalt was combined with nichrome, "advance," constantan, iron, or nickel. The couples were heated in electric furnaces for long periods up to 750 deg. C. and then recalibrated. The recalibration and examination showed that they had all undergone changes; the cobalt became coated with an oxide film, which slightly increased in thickness with the duration of heating. But the thermo-electric changes were small, especially in the cobalt-constantan couple, whilst the iron couple suffered most.

METHODS OF MEASURING AIRCRAFT PERFORMANCES.*

By CAPTAIN H. T. TIZARD, R.F.C.

Aeroplane Testing.—The accurate testing of aeroplanes is one of the many branches of aeronautics which have been greatly developed during the war, and especially during the last year. For some months after the war began a climb to 3,000 ft. to 5,000 ft. by aneroid and a run over a speed course was considered quite a sufficient test of a new aeroplane; now we all realise that for military reasons certainly, and probably for commercial reasons in the future, it is the performance of a machine at far greater heights with which we are mainly concerned. In this paper I propose to give a short general account of some of the methods of testing now in use at the testing squadron of the Royal Flying Corps, and to indicate the way in which results of actual tests may be reduced, so as to represent as accurately as possible the performance of a machine independently of abnormal weather conditions and of the time of the year. For obvious reasons full details of the tests and methods employed cannot yet be given. So far as England is concerned, I believe that the general principles of what may be called the scientific testing of aeroplanes were first laid down at the Royal Aircraft Factory. Our methods of reduction were based on theirs to a considerable extent, with modifications that were agreed upon between us; they have been still further modified since, and recently a joint discussion of the points at issue has led to the naval and military tests being co-ordinated, so that all official tests are now reduced to the same standard. It should be emphasised that once the methods are thought out scientific testing does not really demand any high degree of scientific knowledge; in the end the accuracy of the results really depends upon the flyer, who must be prepared to exercise a care and patience unnecessary in ordinary flying. With careful flyers, whose judgment and reliability you can trust, your task is comparatively easy; with careless flyers it is impossible.

At the outset it may be useful to point out by an example the nature of the problems that arise in aeroplane testing. Suppose that it is desired to find out which of two wing sections is most suitable for a given aeroplane. The aeroplane is tested with one set of wings, which are then replaced by the other set, and the tests repeated some days later. The results might be expressed thus:—

	A Wings.	B Wings.
Speed at 10,000 ft. ...	90 m.p.h.	93 m.p.h.
Rate of climb at 10,000 ft.	250 ft. a minute	300 ft. a minute

Now the intelligent designer knows, or soon will know, that, firstly, an aneroid may indicate extremely misleading "heights," and, secondly, that even if the actual height above the ground is the same in the two tests the actual conditions of atmospheric pressure and temperature may have been very different on the two days. He will therefore say, "What does that 10,000 mean? Do you mean that your aneroid read 10,000 ft., or do you mean 10,000 ft. above the spot you started from, or 10,000 ft. above sea-level?" If he proceeds to think a trifle further he will say, "What was the density of the atmosphere at your 10,000 ft.; was it the same in the two tests? If not, the results do not convey much." There he will touch the keynote of the whole problem, for it is on the density of the atmosphere that the whole performance of an aeroplane depends; the power of the engine and the efficiency of the machine depend essentially on the density, the resistance to the motion of the machine through the air is proportional to the density, and so, finally, is the lift on the wings. None of these properties is proportional solely to the pressure of the atmosphere, but to the density, that is, the weight of air actually present in unit volume. It follows that it is essential when comparing the performances of machines to compare them as far as possible under the same conditions of atmospheric density, not, as is loosely done, at the same height above the earth, since the density of the atmosphere at the same height above the earth may vary considerably on different days, and on the same day at different places.

At the same time, in expressing the final results, this principle may be carried too far. Thus if the speed of a machine were expressed as 40 m. per second at a density of 0.8 kg. per cubic metre, the statement, though it may be strictly and scientifically accurate, will convey nothing to 99 per cent. of those directly concerned with the results of the test. The result is rendered intelligible and, indeed, useful by the form "90 m.p.h. at 10,000 ft.," or whatever it is. With this form of statement, in order that all the statements of results may be consistent and comparative, we must be careful to mean by "10,000 ft." a certain definite density, in fact the average density of the atmosphere at a height of 10,000 ft. above mean sea-level. This is what the problem of "reduction" of tests boils down to; what is the relation between atmospheric density and height above sea-level? This knowledge is obtained from meteorological observations. We have collected all the available data—mostly unpublished—with results shown in Table I.

These are the mean results of a long series of actual observations made by Mr. W. H. Dines, F.R.S. It is convenient to choose some density as standard, call it unity, and refer all other densities as fractions or percentages of this "standard density." We have taken, in conformity with the Royal Aircraft Factory, the density of dry air at 760 mm. pressure and 16 deg. C.

* Paper read before the Aeronautical Society of Great Britain.

TABLE I.—*Mean Atmospheric Pressure, Temperature and Density at Various Heights above Sea-level.*

Height in Kilometres.	Height in Equivalent Feet.	Mean Pressure in Millibars.	Mean Temperature in Absolute Degrees Centigrade.	Mean Density in Kilograms per cubic Metre.
0	0	1,014	282	1.253
1	3,280	900	278	1.128
2	6,560	795	273	1.014
3	9,840	699	268	0.909
4	13,120	615	262	0.818
5	16,400	568	255	0.735
6	19,680	469	248	0.658
7	22,960	407	241	0.589

as our standard density; it is 1.221 kg. per cubic metre. The reason this standard has been taken is that the air speed indicators in use are so constructed as to read correctly at this density, assuming the law:—

$$p = \tfrac{1}{2}\rho V^2$$

where V is the air speed, p the pressure obtained, ρ the standard density.

In some ways it would doubtless be more convenient to take the average density at sea-level as the standard density, but it does not really matter what you take so long as you make your units quite clear. Translated into feet and fractions of the standard density the above table becomes:—

TABLE II.

Height in Feet.	Percentage of Standard Density.
0	102.6
1,000	99.4
2,000	96.3
3,000	93.2
4,000	90.3
5,000	87.4
6,000	84.6
*6,500	83.3
7,000	81.9
8,000	79.2
9,000	76.5
*10,000	74.0
11,000	71.7
12,000	69.5
*13,000	67.3
14,000	65.2
15,000	63.0
16,000	61.1
*16,500	60.1
17,000	59.1
18,000	57.1
19,000	55.2
20,000	53.3

Let us briefly consider what these figures mean. For example, we say that the density of 10,000 ft. is 74 per cent. of our standard density, but it is not meant that at 10,000 ft. above mean sea-level the atmospheric density will always be 74 per cent. of the standard density. Unfortunately for aeroplane tests this is far from true. The atmospheric density at any particular height may vary considerably from season to season, from day to day, and even from hour to hour; what we do mean is that if the density at 10,000 ft. could be measured every day, then the average results would be, as closely as we can tell at present, 74 per cent. of the standard density.

The above table may therefore be taken to represent the conditions prevailing in a "normal" or "standard" atmosphere, and we endeavour, in order to obtain a strict basis of comparison, to reduce all observed aeroplane performances to this standard atmosphere, *i.e.*, to express the final results as the performance which may be expected of the aeroplane on a day on which the atmospheric density at every point is equal to the average density at the point. Some days the aeroplane may put up a better performance, some days a worse, but on the average, if the engine power and other characteristics of the aeroplane remain the same, its performance will be that given.

It must be remembered that a standard atmosphere is a very abnormal occurrence; besides changes in density there may occur up and down air currents which exaggerate or diminish the performance of an aeroplane, and which must be taken carefully into account. They show themselves in an otherwise unaccountable increase or decrease in rate of climb or in full speed flying level at a particular height.

We now pass to the actual tests, beginning with a description of the observations which have to be made and thereafter to the instruments necessary. The tests resolve themselves mainly into—

(*a*) A climbing test at the maximum rate of climb for the machine.

(*b*) Speed tests at various heights from the "ground" or some other agreed low level upwards.

Experience agrees with theory in showing that the best climb is obtained by keeping that which is frequently called the air speed of an aeroplane, namely, the indications of the ordinary air-speed indicator, nearly constant whatever the height. [In other words ρV^2 is kept constant.] We can look at this in this way. There is a limiting height for every aeroplane above which it cannot climb; at this limiting height, called the ceiling of the machine, there is only one speed at which the aeroplane will fly level, at any other air speed higher or lower it will descend. Suppose this speed be 55 m.h.p. on the air-speed indicator. Then the best rate of climb from the ground is obtained by keeping the speed of the machine to a steady indicated 55 m.p.h. Fortunately a variation in the speed does not make very much difference to the rate of climb; for instance, a B.E.2c with a maximum rate of climb at 53 m.p.h. climbs just as fast up, say, to 5,000 ft. at about 58 m.p.h. This is fortunate, as it requires considerable concentration to keep climbing at a steady air speed, especially with a light scout machine; if the air is at all "bumpy" it is impossible. At great heights the air is usually very steady, and it is much easier to keep to one air speed. It is often difficult to judge the best climbing speed of a new machine; flyers differ very much on this point, as on most. The testing squadron, therefore, introduced some time ago a rate of climb indicator intended to show the pilot when he is climbing at the maximum rate. It consists of a thermos flask, communicating with the outer air through a thermometer tube leak. A liquid pressure gauge of small bore indicates the difference of pressure between the inside and outside of the vessel. Now, when climbing, the atmospheric pressure is diminishing steadily; the pressure inside the thermos flask tends, therefore, to become greater than the outside atmospheric pressure. It goes on increasing until air is being forced out through the thermometer tubing at such a rate that the rate of change of pressure inside the flask is equal to the rate of change of atmospheric pressure due to climbing. When climbing at a maximum rate, therefore, the pressure inside the thermos flask is a maximum. The pilot therefore varies his air speed until the liquid in the gauge is as high as possible, and this is the best climbing speed for the machine.

What observations during the test are necessary in order that the results may be reduced to the standard atmosphere? Firstly, we want the time from the start read at intervals, and the height reached noted at the same time. Here we encounter a difficulty at once, for there is no instrument which records height with accuracy. The aneroid is an old friend now of aeronauts as well as of mountaineers, but although it has often been tentatively exposed, it is doubtful whether 1 per cent. of those who use it daily realise how extraordinarily rare it is that it ever does what it is supposed to do, that is, indicate the correct height above the ground or starting-place. The faults of the aeroplane aneroid are partly unavoidable and partly due to those who first laid down the conditions of its manufacture. An aneroid is an instrument which, in the first place, measures only the pressure of the surrounding air. Now if p_1 and p_2 are the pressures at two points in the atmosphere, the difference of height between these points is given very closely by the relation

$$h = k\theta \log_e p_1/p_2$$

where θ is the average temperature, expressed in "absolute" degrees, of the air between the two points and k is a constant. It is obvious that if we wish to graduate an aneroid in feet we must choose arbitrarily some value for θ. The temperature that was originally chosen for aeroplane aneroids was 50 deg. F., or 10 deg. C. An aneroid, as now graduated, will therefore only read the correct height in feet if the atmosphere has a uniform temperature of 50 deg. F. from the ground upwards, and it will be the more inaccurate the greater the average temperature between the ground and the height reached differs from 50 deg. F. Unfortunately 50 deg. F. is much too high an average temperature; to take an extreme example it is only on the hottest days in summer, and even then very rarely, that the average temperature between the ground and 20,000 ft. will be as high as 50 deg. F. On these very rare occasions an aneroid will read approximately correctly at high altitudes; otherwise it will always read too high. In winter it may read on cold days 2,000 ft. too high at 16,000 ft., *i.e.*, it will indicate a height of 18,000 ft. when the real height is only 16,000 ft. It is always necessary, therefore, to "correct" the aneroid readings for temperature. The equation—

$$H = \frac{273 - t}{283} h,$$

gives us the necessary correction. Here H is the true difference in height between any two points, t the average temperature in degrees Centigrade between the points, and h the difference in height indicated by the aneroid. It is convenient to draw a curve showing the necessary correction factors at different temperatures, some of which are given in the following table:—

TABLE III.—*Aneroid Correction Factors.*

Temperature.	Correction Factor.
70 deg. F.	1.040
50 deg. F.	1.000
30 deg. F.	0.961
10 deg. F.	0.922
−10 deg. F.	0.883

For example, if a climb is made through 1,000 ft. by aneroid and the average temperature is 10 deg. F., the actual distance in feet is only $1{,}000 \times 0.922 = 922$ ft. The above equation is probably quite accurate enough for small differences of height—up to 1,000 ft., say—and approximately so for bigger differences.

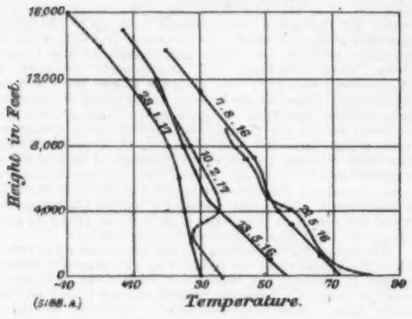
The magnitude of the correction which may be necessary shows how important it is that observations of temperature should be made during every test. For this purpose a special thermometer is attached to a strut of the machine, well away from the fuselage, and so clear of any warm air which may come from the

* 6,500 ft. is introduced as corresponding roughly to the French test height of 2,000 m. 10,000 ft. similarly corresponds roughly to comparing aeroplane test performances to the French standard of 3,000 m., and similarly for 13,000 ft. and 16,500 ft.

engine. The French, I believe, do not measure temperature, but note the ground temperature at the start of a test, and assume a uniform fall of temperature with height. This undoubtedly may lead to serious errors. The change of temperature with height is usually very irregular, and only becomes fairly regular at heights well above 10,000 ft. This is shown by the following curves, which represent results taken at random from tests at different times (Fig. 1).

The aneroid being what it is, one soon comes to the conclusion that the only way to make use of it in aeroplane tests is to treat it purely as a pressure instrument. For this reason it is best to do away with the zero adjustment for all test purposes and lock the instrument so that the zero point on the height scale corresponds to the standard atmospheric pressure of 29.9 in. or 760 mm. of mercury. Every other height then corresponds to a

Fig.1. VARIATIONS OF TEMPERATURES WITH HEIGHT.



definite pressure; for instance, the locked aneroid reads 5,000 ft. when the atmospheric pressure is 24.88 in., and 10,000 ft. when it is 20.70 in., and so on. If the temperature be noted at the same time as the aneroid reading, we then know both the atmospheric pressure and temperature at the point, and hence the density can be calculated, or, more conveniently, read off curves drawn for the purpose. The observations necessary (after noting the gross aeroplane weight, and net or useful weight carried) are therefore: (i) aneroid height every 1,000 ft., (ii) time which has elapsed from the start of the climb, and (iii) temperature; to these should be added also (iv) the air speed and (v) engine revolutions at frequent intervals. The observed times are then plotted on squared paper against the aneroid heights and a curve drawn through them. From this curve the rate of climb at any part (also in aneroid feet) can be obtained by measuring the tangent to the curve at the point. This is done for every 1,000 ft. by aneroid. The true rate of climb is then obtained by multiplying the aneroid rate by the correction factor corresponding to the observed temperature. These true rates are then plotted afresh against standard heights, and from this curve we can obtain the rates of climb corresponding to the standard heights 1,000, 2,000, 3,000, &c. Knowing the change of rate of climb with height, the time to any required height is best obtained by graphical integration. The following table gives the results of an actual test:—

TABLE IV.

Machine..... *Engine*.....

(Date, December 27, 1916.)

Height in Aneroid Feet.	Observed Temperature.	Percentage of Standard Density.	Observed Time.	Rate of Climb in Aneroid.	Real Rate of Climb (Corrected for Temperature).	From Curve.			
						Standard Height.	Percentage of Standard Density.	Time.	Rate of Climb.
	Deg. F			ft.					
0	36		0.0						
1,000	37	101.0	1.0	835	814	1,000	99.40	1.20	775
2,000	38	97.2	2.10	735	718	2,000	96.30	2.56	685
3,000	36	94.0	3.70	640	622	3,000	93.26	4.11	610
4,000	36	90.7	5.40	560	544	4,000	90.25	5.85	545
5,000	36	87.4	7.25	510	495	5,000	87.35	7.80	490
6,000	33	84.7	9.40	450	435	6,000	84.50	9.96	435
7,000	30	82.1	11.90	405	389	7,000	81.80	12.40	385
8,000	26	79.9	14.25	365	347	8,000	79.16	15.14	345
9,000	22	77.6	17.00	330	312	9,000	76.55	18.20	310
10,000	23	74.7	20.25	310	294	10,000	74.00	21.61	280
11,000	21	72.2	23.60	280	264	11,000	71.70	25.41	245
12,000	20	69.8	27.40	230	213	12,000	69.50	29.81	210
13,000	17	67.7	31.90	195	182	13,000	67.32	35.13	170
14,000	12	65.9	37.90	130	130	14,000	65.17	41.88	130
15,000	8	64.1	45.25	110	101	14,500	64.11	46.23	105

The corrections are often much greater than those necessary in the above case.

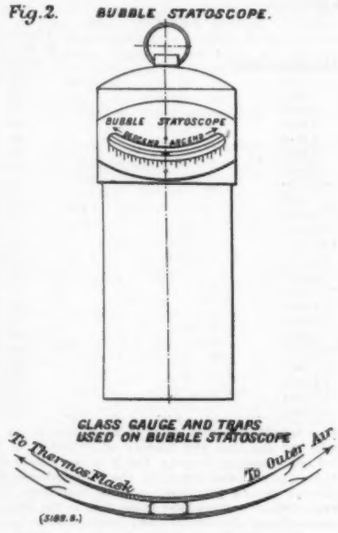
It will be noticed that the rate of climb of this machine is approximately halved for a difference in height of 5,000 ft. Now it is possible to get a difference in density near the ground of as much as 15 per cent. between a hot day in summer and a cold day in winter. This corresponds to a difference in height of 5,000 ft. (see Table II), so that this machine would climb off the ground on a hot day at only half the rate that it would on a very cold day. Variation in atmospheric density, combined with the errors of an aneroid, fully account for the observed difference between a "good climbing day" and a "bad climbing day."

At least two climbing tests of every new machine are carried out up to 16,000 ft. or over by aneroid. If time permits three or more tests are made. The final results given are the average of the tests and represent as closely as possible the performance on a standard day, with temperature effects, up and down currents and other errors eliminated.

If we produce the rate of climb curve upwards it cuts the height axis at a point at which the rate of climb would be zero, and therefore the limit of climb reached. This is the "ceiling" of the machine.

Speeds.—His 16,000 ft., or whatever it is, reached, the flyer's next duty is to measure the speed-flying level by air-speed indicator at regular intervals of height (generally every 2,000 ft.) from the highest point downwards. To do this he requires a sensitive instrument which will tell him when he is flying level. The aneroid is quite useless for this purpose, and a "statoscope" is used. The principle of this instrument is really the same as that of a climbmeter. It consists of a thermos flask connected to a small glass gauge, slightly curved, but placed about horizontally. In this gauge is a small drop of liquid, and at either end are two glass traps which prevent the liquid from escaping either into the outside air or into the thermos flask. As the machine ascends the atmospheric pressure becomes smaller, and the

Fig.2. BUBBLE STATOSCOPE.



pressure in the flask being then higher than the external pressure, the liquid is pushed up to the right-hand trap, where it breaks, allowing the air to escape. On descending the reverse happens; the liquid travels to the left, breaks, and air enters the flask. When flying truly level the drop remains stationary, moving neither up nor down. The instrument is made by the British Wright Company.

The flyer or the observer notes the maximum speed by the air-speed indicator, *i.e.*, the speed at full engine throttle. At one or more heights, also, he observes the speeds at various positions of the throttle down to the minimum speed which will keep the machine flying at the height in question. The petrol consumption and the engine revolutions are noted at the same time, as well, of course, as the aneroid height and temperature. Accurate observation of speeds needs very careful flying—in fact much more so than in climbing tests. If the air is at all bumpy observations are necessarily subject to much greater error, since the machine is always accelerating and decelerating. The best way to carry out the test seems to be as follows. The machine is flown first just down hill and then just up hill and the air speeds noted. This will give a small range between which the real level speed must lie. The flyer must then keep the speed as steadily as possible on a reading midway between these limits, and watch the statoscope with his other eye. If it shows steady movement, one way or the other, the air speed must be altered accordingly by 1 m.p.h. In this way it is always possible at heights where the air is steady to obtain the reading correct, at any rate to 1 m.p.h., even with light machines, provided always sufficient patience is exercised. The revolutions at this speed are then noted.

One difficulty, however, cannot be avoided. If at any height there is a steady up or down air current, then though the air may appear calm, *i.e.*, there may be no "bumps," the air-speed indicator reading may be wrong, since to keep the machine level in an up-current it is necessary to fly slightly down hill relatively to the air. Such unavoidable errors are, however, eliminated to a large extent by the method of taking speeds every 2,000 ft. and finally averaging the results.

We must now consider how the true speed of the aeroplane is deduced from the reading of the air-speed indicator. It is well known that an air-speed indicator reads too low at great heights—for example, if it reads 70 m.p.h. at 8,000 ft. the real speed of the machine through the air is nearer 80 m.p.h. The reason for this is that the indicator, like the aneroid, is only a pressure gauge—a sensitive pressure gauge, in fact, which registers the difference of pressure between the air in a tube with its open end pointing forward along the lines of flight of the machine and the real pressure (the static pressure) of the external air. This difference of pressure is, as nearly as we can judge by experiment $= \frac{1}{2}\rho V^2$ (where ρ is the density of the air and V the speed of the machine), provided that the open end of the tube is well clear of wings, struts, fuselage, &c., and so is not affected by eddies and other disturbances. Now assuming this law, air-speed indicators are graduated to read correctly, as I have said above, at a density of 1.221 kg. per cubic metre, which we have taken as our standard density and called "unity." It corresponds on an average to a height of about 800 ft. above sea-level.

Then suppose the real air speed of an aeroplane at a height of A feet is V m.p.h., and the indicated air speed is 70 m.p.h., this means that the excess pressure in the tube due to the speed is proportional to 1×70^2,

$$\text{or } \rho \times V^2 = 1 \times 70^2,$$

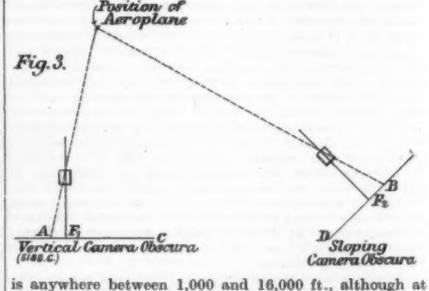
where ρ is the density at the height in question, expressed as a fraction of the standard density. To correct the observed speed we therefore divide the reading by the square root of the density. Thus observation of the maximum speed of an aeroplane at a height of 8,000 ft. by the locked aneroid gave 80 m.p.h. on the indicator, the temperature being 31 deg. F. From the curve we find that the density corresponding to 8,000 ft. and 31 deg. is 0.85 of standard density. The corrected air-speed is therefore

$$= \frac{80}{\sqrt{0.85}} = 86.7 \text{ m.p.h.}$$

This "corrected" air speed will only be true if the above law holds, that is to say, if there are no disturbances due to the pressure head being in close proximity to struts or wings. It is always necessary to find out the magnitude of this possible error; that is, to calibrate the air-speed indicator, and the only way to do this is to measure a real air speed of the aeroplane at some reasonable altitude for easy observation by actual timed observations from the ground, and from these timed results to check those deduced from the air-speed indicator readings. This calibration is the most important and difficult test of all, since on the accuracy of the results depends the accuracy of all the other speed measurements. It can either be done by speed trials over a speed course close to the ground, or when the aeroplane is flying at a considerable height above the ground. In the testing squadron we have till lately attached more importance to the latter method, mainly because the conditions approximate more to the conditions of the ordinary air speed measurements at different heights, and because the weather conditions are much steadier and the flyer can devote more attention to flying the machine at a constant air speed than he can when very close to the ground.

One method is to use two camera obscuras, one of which points vertically upwards and the other is set up sloping towards the vertical camera. At one important testing centre the cameras are about ¾-mile apart, and the angle of the sloping camera is 45 deg. By this arrangement, if an aeroplane is directly over the vertical camera it will be seen in the field of the sloping camera if its height

Fig.3.



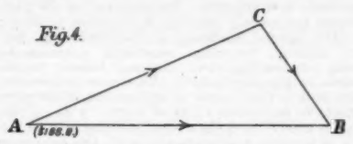
is anywhere between 1,000 and 16,000 ft., although at very great heights it would be too indistinct for measurements except on a very clear day. The height the tests are usually carried out is 4,000 ft. to 6,000 ft.

The aeroplane is flown as nearly as possible directly over the vertical camera, and in a direction approximately at right angles to the line joining the two cameras. The pilot flies in as straight a line and at as constant an air speed as he can. Observers in the two cameras dot in the position of the aeroplane every second. A line is drawn on the tables of each camera pointing directly towards the other camera, so that if the image of the aeroplane is seen to cross the lines in the one camera it crosses the line in the other simultaneously. From these observations it is possible to calculate the height of the aeroplane with considerable accuracy; the error can be brought down to less than one part in a thousand with care. Knowing the height, we can then calculate the speed over the ground of the aeroplane by measuring the average distance on the paper passed over per second by the image in the vertical camera. If x in. is this distance, and f the focal length of the lens, the ground speed is $x \times h/f$ ft. per second.

It is necessary to know also the speed and direction of the wind at the height of the test. For this purpose the pilot or his observer fires a smoke puff slightly upwards when over the cameras, and the observer in the vertical camera dots in its trail every second. The height of the smoke puff is assumed to be the same as

that of the aeroplane—it probably does not differ from this enough to introduce any appreciable error in the results. The true speed through the air is then found graphically as shown in Fig. 4. Here the length A B represents the ground speed of the aeroplane as measured in the camera and C B represents on the same scale the velocity and direction of the wind. The length A C represents, also on the same scale, the true air speed of the machine.

Fig.4.



A B represents the measured speed of the aeroplane on the ground; C B on the same scale represents the velocity and direction of the wind; therefore A C represents the real speed of the aeroplane through the air.

The tests are done in any direction relative to the wind, and generally at three air speeds, four runs being made at each air speed.

The advantages of this method are :—

1. Being well above the earth the pilot can devote his whole attention to the test.

2. Within reasonable limits any height can be chosen, so that it is generally possible to find a height at which the wind is steady.

3. It does not matter if the pilot does not fly along a level path so long as he does so approximately. What is more important is that he should fly at a constant air speed.

4. It is not necessary that there should be any communication between the two cameras, although it is convenient. The two tracks are made quite independently, and synchronised afterwards from the knowledge that the image must have passed over the centre line simultaneously in the two cameras.

The main disadvantage is that somewhat elaborate apparatus is necessary, but this is of not much importance in a permanent testing station.

There are often periods in war time, however, when an aeroplane has to be tested quickly, and low cloud layers and other causes prevent the camera test from being carried out. It is then necessary to rely on measurements of speeds near the ground for the calibration of the air-speed indicator. In this method the aeroplane is flown about 50 ft. off the ground, and is timed over a measured run. There are two observers, one at each end of the course ; when the aeroplane passes the starting-point the observer sends a signal and starts his stop-watch simultaneously ; the second observer starts his stop-watch directly he hears the signal, and in his turn sends a signal and stops his watch when the aeroplane passes the finishing-point. By this double timing errors due to the so-called "reaction time" of the observers are practically eliminated, for the observer at the end of the course tends to start his watch late, while the first observer stops his late. The mean of the two observations gives the real time. Four runs, two each up and down the course, are done at each air speed, the pilot or his observer noting carefully the average air speed during the run. Observations of the atmospheric pressure and temperature, from which the density can be obtained, are also taken. The average strength and direction of the wind during each trial are noted from a small direct reading (or recording) anemometer and the speed corrected in the same way as in the camera tests. If there is a strong cross wind the aeroplane may have to be pointed at a considerable angle to the course, and this makes the test a very difficult one to carry out well. Generally speaking, it is only reliable when the wind is quite light, not more, at any rate, than 10 m.p.h. Even this is too strong if it is a cross wind.

A further difficulty is that at high speeds, over 100 m.p.h., an aeroplane may take quite a considerable time to accelerate up to a steady speed, and so it must fly level for a long distance each end before reaching the actual course. At the testing station previously alluded to the course is a mile long, and there is a clear half-mile or more at each end, but it is doubtful whether even this distance is enough for the machine to attain steady speed before the starting-point. Finally, the flyer of a single-seater is generally too busy watching the ground to do more than glance at his air-speed indicator more than a few times during the run. Doubtless it would be better in such a case to use some form of recording air-speed instrument, although then other difficulties would arise.

Having got the true air speed from camera or speed-course tests, and knowing the density at the height at which the test was carried out, we obtain what the air-speed indicator should have read by multiplying the measured air speed by the square root of the density. By comparing this with the actual reading of the indicator we obtain the necessary correction. The whole procedure may be shown best by a table giving part of the results of a camera test made at the beginning of the year.

A summary of the complete speed tests may now be given. Firstly, the air speed and engine revolutions are noted flying level at full throttle every 2,000 ft. approximately by aneroid. From the aneroid reading and the temperature observations at each height the density is obtained. The reading of the air-speed indicator is then first corrected for instrumental errors by adding or subtracting the correction found by calibration tests over the cameras or speed course. This number is then again corrected for height by dividing by the square root of the density. The result should give the true air speed, subject, of course, to errors of observation. The numbers

TABLE V.—CALIBRATION TEST OF AIR-SPEED INDICATOR NO..... ON.....MACHINE.
(Date, December 24, 1916.)

Run No.	Measured Ground Speed.	Measured Wind Speed and Direction.	Corrected True (= V) Air Speed.	Observed Aneroid Height.	Observed Tempera-ture.	Density (= ρ) Referred to Standard Density.	Observed Air Speed.	V × √ρ	Correction Necessary.
	m.p.h.								
1	89.1	31.0 m.p.h. 161.5	89.2	5,100	31	0.879	80.0	83.6	+ 3.6
2	123.4	28.6 ,, 5.5	93.7	5,100	31	0.879	85.0	87.8	+ 2.8
3	62.0	32.3 ,, 168.5	93.8	5,050	31	0.881	85.0	88.1	+ 3.1
4	124.7	32.3 ,, 21.0	95.6	5,000	31	0.882	86.0	88.8	+ 2.8
								Mean	+ 3.1

TABLE VI.—AIR SPEEDS AT HEIGHTS. (Date, December 27, 1916.)

Aneroid Height.	Tempera-ture Observed.	Standard Density.	Corres-ponding Standard Height.	Observed Air Speed.	Correction for Error of In-strument.	Correction for Density.	Observed R.P.M.	Final Results from Curve.		
								Standard Height.	Air Speed.	R.P.M.
	Deg. F.			m.p.h.					m.p.h.	
3,000	39	0.935	2,900	95	98	101½	1,280	3,000	103.0	1,290
5,000	35	0.875	4,900	93	96	102½	1,280	6,500	100.5	1,250
7,000	30	0.821	6,900	88	91	100½	1,240	10,000	96.5	1,215
9,200	24	0.767	9,000	81	84	96	1,220	13,000	94.5	1,180
10,800	19	0.731	10,400	80	83	97	1,220	15,000	88.0	1,160
12,800	17	0.682	12,000	72	76	92	1,200			
13,800	12	0.664	13,400	68	72	88½	1,180			
15,200	8	0.636	14,800	65	69	86½	1,160			

Fig.5. AIRSPEEDS AT HEIGHTS 27. 12. 16.

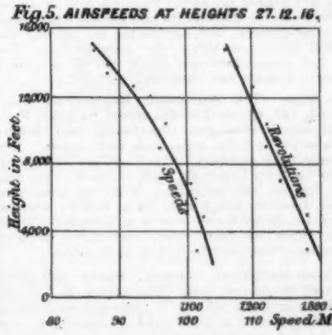
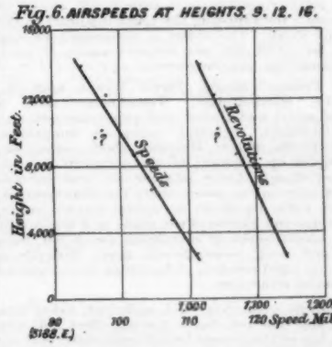


Fig.6. AIRSPEEDS AT HEIGHTS. 9. 12. 16.



so obtained are plotted against the "standard" heights, i.e., the average height in feet corresponding to the density during the test. A smooth curve is then drawn through the points and the air speeds at standard heights of 3,000, 6,500, 10,000, 13,000 and 16,500 read off the curve. These heights are chosen because they correspond closely with 1 km., 2 km., 3 km., &c. The indicated engine revolutions are also plotted against the standard heights, because these observations form a check on the reliability of the results ; also the ratio of speed to engine revolutions at different heights may give valuable information with regard to the propeller.

Table VI gives complete results of one of our tests of air speed at heights. The table refers to the same machine as Table V, which gives the results of calibration tests of the air-speed indicator. Fig. 5 shows the smooth curve drawn from the calculated data, the actual air speeds calculated from the observations being shown by crosses, while the observed engine revolutions at the same heights are marked in by dots. Fig. 6 gives another example, where the observations were very good ; the air speeds and revolutions per minute lie very closely on a smooth curve except at one point (about 10,000 ft.) where they were probably affected by a downward current of air.

In a brief paper it is impossible to do more than explain the more important of the "performance" tests of aeroplanes, considered solely as flying machines. For military purposes a number of tests are necessary, some of which cannot easily be reduced to figures. Nor can it be supposed for an instant that the methods outlined here are final ; aeroplane testing, like all other work connected with aeroplanes, is only in its infancy ; and as time goes on, and knowledge accumulates, better methods and instruments will be evolved. There are some who lay considerable emphasis on the necessity of every test instrument being self-recording, and although this scheme appears at first sight Utopian and would relieve the pilot of a single-seater of considerable trouble, there are many objections to it when considered in detail, not the least of which is the difficulty of getting new and elaborate instruments made at a time when all manufacturers are fully engaged on other important work. When an observer can be taken I would personally place much more reliance on direct observations at the present time, and one great advantage of direct observation is that the results are there, and no time is lost through the failure of a recording instrument to record, a circumstance which is not unknown in practice. So far as we use recording instruments, we use them only as a check on direct observations, although we may probably adopt recording air-speed indicators for the calibration tests of single-seaters. But whether recording or direct-reading instruments are used, it is, as I said before, the flyer on whom the accuracy of the tests depends. I feel that too great stress cannot be laid on this ; he is the man who does most of the experiments, and, like all experimenters in every branch of science, he requires training and a great deal of practice. Although the methods themselves may be greatly changed, this much may perhaps be claimed, that the general principles on which they are founded are sound, and will only be altered in detail. The importance of the work can hardly be exaggerated ; model experiments are notoriously subject to scale and other corrections, which if not carefully scrutinised may be very misleading, and it is only by accurate full-scale work in addition that we can hope to maintain a steady improvement in the efficiency of aeroplanes.

NORWEGIAN SHIPPING AND THE WAR.—Up to July 14, 1917, 448 Norwegian steamers and 148 sail and motor vessels, with an aggregate tonnage of 855,813 tons, have been lost through the effects of the war, and 640 men and women have perished through these losses of tonnage.

GERMAN STEAMERS IN NETHERLANDS INDIA.—It will be remembered, says *The London and China Telegraph*, that Germany offered recently to Holland seven German steamers lying in Dutch East Indian harbours as compensation for the seven Dutch steamers sunk on February 22 this year by German submarines off Falmouth. This would appear to be rather cheap compensation on Germany's part, from the following account given in the Amsterdam *Telegraaf* of July 31 by a Dutch East Indian visitor in Holland. He says : "A Dutch East Indian cannot help smiling when he finds fear expressed that the German and Austrian ships which sought refuge in East Indian harbours might run out to sea as raiders. About forty steamers fled into our harbours. In the Emma Harbour and the Queen's Bay at Padang are lying the Von Kleist and Rheinland, of the North-German Lloyd, the Ninivé, of the Hamburg-America Line, and an Austrian boat from Fiume, the Orsowa. The Von Kleist was lying before Colombo when she received warning telegrams, and she ran full speed to Padang. It will not be long before those ships require no more watching. The vegetative power of the tropical flora is so overwhelming that unused buildings are in a short time covered with foliage. Not less luxuriant is the growth of shells and corals. It is not unusual to find old crocodiles with an armour of shells. The steamers lying idle must now be crusted with a layer of coral and shell of from 20 in. to 30 in. thick. About a year ago attempts were made under supervision of the harbour authorities to get some movement in the Von Kleist. After many days' work no greater speed than five knots could be got out of her, although the ship originally had a speed of 20 knots. Danger of their escape as fast running raiders exists only in the imagination of the ignorant. The Germans may be happy if the ships can be used again after months of cleaning in dock."

TUNGSTEN ALLOYS AND COMPOUNDS.

Alloys of tungsten can be formed of the two elements tungsten and molybdenum by compressing a mixed, reduced powder of both into briquettes, and then heating them with an electric current in an atmosphere of hydrogen. Alloys can be prepared varying in composition from 100 per cent. of tungsten to 100 per cent. molybdenum. Thermal and microscopical analyses show that tungsten and molybdenum are completely isomorphous. All the alloys of this series are malleable and ductile under proper conditions. Alloys of tungsten were suggested as substitutes for platinum and its alloys when the price of the latter approximated to 18*l.* or more per ounce refined. It has been ascertained that except in two respects pure ductile tungsten may be made to meet all the requirements of a practical substitute for platinum and its alloys. These two defects are its relative ease of oxidation and the difficulty with which it can be soldered, but both would appear to have been overcome by coating with a precious metal or alloy; the resulting material, it is claimed, being in many respects even superior to platinum or its alloys. When the metal tungsten is required for alloying with other metals, such as iron, the oxides of iron, manganese and calcium with which it occurs in combination as an ore have to be removed. The oxygen has to be removed either from the tungsten oxide after that has been separated from the other oxides, or by removal of the combined oxides and the production directly of an alloy of tungsten and iron known as ferro-tungsten. The manufacture of tungsten on a commercial scale was originally made possible by the introduction of the electric furnace, in which the metal was melted in a vacuum. The manufacture of ferro-tungsten depends to a considerable extent on this form of furnace. Tungsten alloys are made in part at the Niagara Falls and wherever water power on a large scale is available; when they are made elsewhere metallic aluminium is largely used as a reducing agent, which is also a water-power product.

The most important application of tungsten is for the production of tungsten steel; quite recently molybdenum has been suggested as a substitute owing to the high price and limited supply of tungsten. An important steel-tungsten alloy containing 7 per cent. of the latter and 1½ per cent. of carbon is more especially suited for magnets, owing to its great retentivity of residual magnetism, which renders it very suitable for the fields of magnetos of motor cars. For machine-cutting tools an alloy of tungsten-chrome steel is obtained from 15 per cent. tungsten, 6 per cent. chromium, 1 per cent. manganese, and 0.68 per cent. carbon. The tungsten contents of many high-speed steels of the best qualities vary between 18 per cent. and 20 per cent. Other uses for tungsten are in the production of electric furnaces, electric contacts, and targets for Röntgen rays.

Tungsten compounds combined with sodium are largely employed for impregnating fibres to render them fireproof. They are also used as a mordant in dyeing. The reduction of the potassium tungstates by fusing them with pure tin gives rise to peculiar compounds of various colours, which are known as tungsten bronzes; they are largely employed as pigments, also for the manufacture of bronze powders for decorative purposes. The polytungstates are most suitable for this purpose. The so-called magenta bronze, which is much in demand, is produced by adding tungsten trioxide to fused potassium until no more can be dissolved; it is then gently heated in a current of hydrogen gas and digested with water, hydrochloric acid and potash, which operation leaves small violet crystals, with a delicate copper lustre, of $K_2W_4O_{12}$.

Pure tungsten has been produced which is so ductile that it can be drawn into the finest wire, possessing extraordinary tensile strength. Diamonds are used as dies in drawing tungsten wire. Some years ago it did not appear possible to drill holes small enough through diamonds to produce wire sufficiently fine to render it available for lamps of limited candle-power; but wire 0.0006 in. in diameter is possible and can be drawn in quantity. In the manufacture of tungsten lamps during 1915 it has been estimated that 4½ tons of tungsten were consumed. This tungsten wire has many points to recommend it: it is practically insoluble in all the common acids, its melting-point is higher than that of any other metal, and its tensile strength exceeds that of iron and nickel. It is also paramagnetic; it can be drawn to smaller sizes than any other metal, whilst its specific gravity is 70 per cent. higher than that of lead. Its great hardness and high heat conductivity render it serviceable for many purposes. Tungsten resisters of two types have been designed for electric laboratory furnaces. In one, tungsten wire is wound on an aluminium tube in an airtight box with a hydrogen atmosphere. In the other a tungsten metal tube is substituted for the helical carbon resister in an Arsem vacuum furnace. Tungsten-molybdenum thermo-couples have been suggested; the electromotive force increases with the temperature up to about 540 deg., then decreases and passes through 0 millivolts at about 1,300 deg.

CATALOGUES.

Card Index Signals.—Messrs. Tapp and Toothill, Limited, 320, Brixton-road, London, S.W., send particulars of small metallic clips, in various colours, for attachment to cards in a card index drawer to indicate matters requiring special attention.

Stoking Machines.—Messrs. Scholey and Co., Limited, 56, Victoria-street, London, S.W., send four little leaflets explaining the merits of the "Taylor Stoker," especially its easy adjustment for economising fuel when the load is light and forcing rapid consumption when the load is heavy.

Warehousing Accommodation.—The Port of Manchester Warehouses, Limited, Trafford Park-road, Manchester, send a booklet of photograph views of their warehouses, fireproof arrangements and lifting and conveying plant. The capacity of the closed warehouses is now over 400,000 tons, and there is also ample open storage ground. Iron, steel and machinery bulk largely in the great variety of goods for which special arrangements are made. Special rails are run from the warehouses to ship side and railway lines.

Overhead Travelling Cranes.—The Brown Hoisting Machinery Company, Cleveland, U.S.A., send a catalogue of end trucks, trolleys, chain blocks, wall brackets and other parts for hand-worked overhead travelling cranes. The fittings are graded for about fourteen sizes of crane, ranging from 5-cwt. to 20-ton lifts and for use with single or double cross-girders, and applicable for placing the hoisting gear above or below the cross-girders. For each part full particulars are given of all necessary measurements, weights and capacity.

Grinding Mills.—The Sturtevant Engineering Company, Limited, 147, Queen Victoria-street, London, E.C., send an abridged catalogue illustrating and briefly describing a series of mills, separators and mixers. The mills include roll-jaw crushers for rock and ore; hammer-bar mills for medium materials such as chalk, bark and coal; coal crusher and sampler; crushing rolls from 8 in. to 32 in. diameter and 5 in. to 16 in. width; vertical and horizontal mills with rock-emery millstones. There are several types of each class, and fully detailed catalogues of any class may be had on application.

Motor-Wheel Mudguards.—Messrs. Hardy and Padmore, Limited, Worcester, send illustrations of a device for fixing to motor-car wheels to prevent mud being splashed. The guard is a brush made in ring form, and is attached to and revolves with the wheel, the bristles barely touching the road. The brush rim is either a continuous solid ring for pneumatic-tyred wheels or in four segments for adjusting the brush diameter to the wear of solid tyres. The object is apparently to stop what may be called the long-distance squirt of mud, which is so annoying and dangerous.

Building Frames.—Messrs. David Rowell and Co., Limited, 14, Howick-place, Westminster, send a catalogue of metal and timber roof principals and also complete buildings, including complete bungalows, cottages, hospitals, schools, churches, sheds, barns, &c. These are fitted up complete at the company's works, the standard designs being adapted to local circumstances, and sent out in pieces ready for final erection. Roofing and walls are given in several kinds; stairs, fencing, railings and gateways are made in a number of designs. A special series of ventilators are shown, both automatic and with power-driven fans. Everything is provided for rapid erection of buildings, from light to very substantial structures.

Reflected Light.—An even and sufficient light, free from glares and shadows, has a marked effect not only on the eyes, but on the general health and temper of those working in it. Of late years much attention has been given to the production or arrangement of better light, and it must be admitted that most employers are showing a disposition to spend money freely in securing the advantages. The subject is fully dealt with in a catalogue issued by the British Thomson-Houston Company, Limited, 77, Upper Thames-street, London, E.C. 4. A very complete range of fittings is illustrated, with full particulars of sizes, capacity, &c., of each. The essential part is the reflector made of glass, with combined spiral and vertical corrugations backed with pure silver deposit secured with enamel. The same firm send another catalogue dealing with fittings for half-watt type lamps for use on alternating-current or direct-current circuits, in sizes from 15 watts to 1,500 watts.

Electric Signalling in Mines.—A system of signalling for use in underground haulage is explained in a catalogue received from the General Electric Company, Limited, Witton, Birmingham. A single line serves both for carrying the current and as a pull wire. A closed circuit is used, beginning from earth to a battery of four Carsak or ordinary Leclanché cells, continuing through interruptors (a special patent) at various points in the line and in series with all the relays on the system, and finishing with either an efficient earth point or, in very dry pits, a return wire. A signal can be given from any part of the line by pulling the line wire. One line wire only is necessary, and the E.M.F. need not exceed 6 volts. Sparking in the line wire is eliminated. If the line wire is accidentally broken or earthed all the bells will ring continuously until attended to. Signals can be given up to the fault, so that the defect is easily located. A large diagram of the system is inserted in the catalogue. A leaflet from the same makers shows a series of terminal blocks without or with metal parts, neatly made and very inexpensive.

Wood-Working Machinery.—The J. A. Fay and Egan Company, Cincinnati, U.S.A., send a catalogue containing illustrations and particulars of a very wide range of wood-working machines, cutter heads, tool-dressing machines and some line-shaft fittings, safeguards, and small tools and supplies. In addition to the principal machines for sawing, planing, boring and turning there are many special machines for sandpapering, pin and dowel making, tenoning, mortising, mitreing, spoke-shaping, dovetailing and copying lathes (known in America as gauging lathes). The chief interest of the catalogue is in the variety of adaptations of the principal machines to particular kinds of work. A swing cutting-off saw is shown carrying a small circular saw on a frame which is pivoted concentrically with the countershaft; the frame swings on sleevelike projections from the hangers. There is also a special silver solder and flux for joining band saws.

Faults in Electric Motor Control Gear.—A useful pamphlet for engineers in charge of electrical machinery has been reissued by the firm of George Ellison, Wellhead-lane, Perry Bar, Birmingham. It contains a very clear discussion of the faults likely to arise when installing the gear or through wear, neglect or improper use, and explains both remedies and preventatives. Faults which indicate that the gear in use is insufficient or unsuitable are carefully detailed. In point of literary style this pamphlet is remarkably good; the language is simple and unaffected, the matter is well arranged, and there is an easy, direct candour about it which gives a pleasant literary flavour to the discussion of a subject that is not at all simple. The writer allows that at least some of the Home Office rules are wise and admits that electrical machinery is not perfect; he also manages to suggest, without the least offence, that electrical engineers are not always perfect. The advice is not narrowed down to the firm's own gear, but is made generally useful. A copy would, no doubt, be sent by the firm to any of our readers who are practically interested. The same firm send us a catalogue of electric cable fittings, pipe flanges, sealing and dividing boxes, armour clamps, glands, &c., with many technical particulars and instructions for fitting.

Concrete Reinforcement.—The British Reinforced Concrete Engineering Company, Limited, 36, Lime-street, London, and 1, Dickinson-street and Trafford Park, Manchester, send a large number of illustrations of buildings, reservoirs, water towers, sea walls, piers, bridges, culverts, &c., in which their steel reinforcements are used in the concrete work. Columns are reinforced with plain bars of circular section, spaced and held with helical wrapping and looped hoops; beams with plain bars and S-clip stirrups; and slabs with "fabric." The fabric is made of mild steel wire, the longitudinals being of heavier section than the cross wires. At the point of crossing the wires are electrically welded. The rolls of material are 84 in. wide and made in 14 diameters of wire, from 4/0 to 10 gauge. A leaflet accompanying the book gives a table of the diameters and square sectional areas of the wires, with the safe tensile strength per foot width of fabric for each of the 14 sizes. A series of tables are also given showing the fabric suitable for eight classes of work, including floors of dwellings, warehouses, public buildings, heavy machinery floors, &c., and also for roofs. A pamphlet issued by the same firm shows a test to destruction of a floor reinforced with this fabric, the conclusion being that the fabric is 50 per cent. stronger than the same weight of steel used for the same purpose in the form of rods.

Soda Manufacture in Norway.—The first soda factory is about to be started in Norway, under the auspices of the large Norwegian Hydro Company. Comprehensive experiments have been undertaken before this manufacture was decided upon, but on account of the influence of the war upon this industry the prospects are looked upon as promising. The production in the meantime is estimated at about 5 tons per day.

The First Ferro-Concrete Floating Dock.—The launch of the first ferro-concrete floating dock has just taken place at the shipyard at Moss, Norway. It has been built for account of a Christiania boatbuilding concern, and is not of imposing dimensions, the length being only 80 ft., inside breadth 25 ft., and inside height 16 ft. It has a lifting power of some 100 tons, and has in the meantime been tested with one of the company's 100-ton ferro-concrete lighters. Already numerous inquiries have been received for ferro-concrete floating docks of as much as 8,000 tons capacity. The Moss yard, which some time ago, though quite a new concern, found it expedient to increase its capital, has now bought an adjoining site especially with a view to the building of such floating docks. The structure now completed is divided into a number of watertight compartments, each with its own outlet pipe, all the pipes leading into the pump chamber. The centrifugal pump is able to lift the floating dock with its vessel in the course of an hour. The pump is worked by an electric motor, which receives the current from a generator on shore. Water for submerging enters through outside sluices, of which four are placed at the respective corners of the dock, two large sluices distributing the water from the pump chamber to the nine watertight compartments. The outlet pipes are also made of ferro-concrete. Ferro-concrete is evidently better adapted for floating docks than for vessels, although many attempts are being made with the latter object, as our columns have recently shown.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

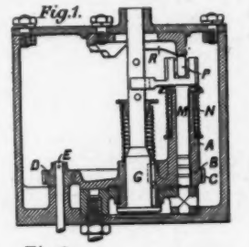
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

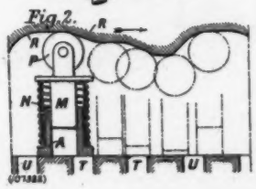
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

GAS ENGINES, PRODUCERS, HOLDERS, &c.

107,322. Albion Motor Car Company, Limited, and T. B. Murray, Scotstoun, Glasgow. Mechanical Feed Lubricators. (2 *Figs.*) October 20, 1916.—The invention relates to mechanical feed lubricators in which there is a pump, the plunger of which is moved over a cam track to deliver oil to a series of delivery ports controlled by that movement (its suction stroke being spring-operated), and has for its object so to modify the cam track and parts that a greater number of pump-fed delivery ports may be arranged within a given space. According to the invention, for each charging port U through which the plunger M draws its charge of oil there is a plurality of discharging ports T, brought into communication successively. The cam track R is formed with a corresponding series of surfaces acting for delivery of like or varying amounts separated by flats during which no action takes place while the pump passes from port to port. The pump cylinder A is formed on a base B, about the periphery of which are cut teeth C, with which gears a driving

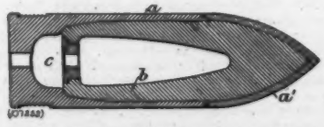




pinion D on a shaft E. The base B rotates upon a spindle G. The plunger M operates in the cylinder A under control of a spring N, which keeps a roller P carried by it in constant contact with the cam track R. It will be seen in Fig. 2 that there are two delivery ports T in the base B for each inlet port U. It will be seen that the cylinder A, having just passed an inlet port U and received its charge, has just become uncovered to a delivery port T. The part of the cam track R operative while the cylinder is traversing this port is such that it moves the plunger M one-half of its stroke for discharge. A flat then supervenes on the cam track, and meanwhile the cylinder moves on to the second delivery port T, where, owing to the shape of the cam track, the second half of the delivery stroke is accomplished. A flat on the cam track again intervenes, and the cylinder then reaches the second inlet port U, opposite which the cam track is so formed that the plunger M is permitted to rise under the impulse of the spring N, and the suction stroke is performed. (*Accepted July 4, 1917.*)

GUNS AND EXPLOSIVES.

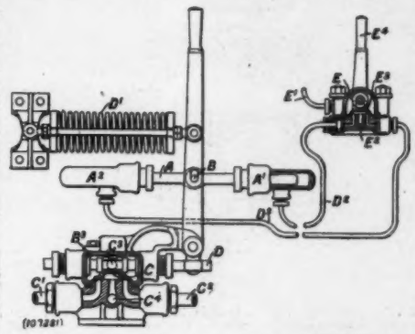
107,252. W. Warburton, Streatham Common, London, and H. Warburton, Sheffield. Armour-Piercing Projectiles. (1 *Fig.*) June 27, 1916.—This invention relates to armour-piercing bursting shells or projectiles of the type in which an inner or secondary projectile is given an impetus after the primary energy imparted to the major projectile has been dissipated on coming in contact with the armour or other object at which it is fired, said secondary projectile subsequently being shattered by the explosion of an internal charge. The improved projectile is comprised of two principal portions, one being the outer or



main projectile *a*, which forms a casing or envelope for an inner or secondary bursting projectile *b*. The outer projectile *a* is of the usual conventional form on its exterior, and is made in two parts, *a*, *a*1, screwed together at about the shoulder of the projectile. The internal cavity is made of a form to correspond exactly to a projectile *b*, fitted in same except that a recess *c* is left at the rear end of the cavity for the reception of a propellant charge and an ordinary service percussion fuse for propelling the inner or secondary projectile *b*, and also for igniting a time fuse carried by the inner projectile. (*Accepted July 4, 1917.*)

LIFTING AND HAULING APPLIANCES.

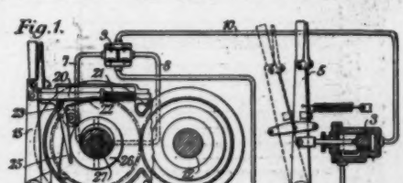
107,281. Brown Brothers and Company, Limited, and W. Wallace, Edinburgh. Lifts. (2 *Figs.*) July 27, 1916.—This invention has for its object to provide a simple and reliable fluid-pressure operated apparatus for controlling fluid-pressure operated machines, such as lifts, from a distance. A double-ended ram A operates in two opposed cylinders A1, A2. This ram is pivotally connected to a hand lever B pivoted on a valve-box B3, in which is a slide valve C capable of alternately connecting two pipes C1, C2, either to the pressure inlet C5 or to the exhaust outlet C4. This valve C may either be the main valve controlling the movements of the lifting and lowering rams (not shown) of the apparatus, or it may be a relay valve controlling in turn the movement of the main valve. The hand lever B is connected to the spindle D of the valve C and operates that valve. A centering spring device D1—of the well-known type as applied to telemotors—is also connected to the hand lever B. Any movement of the hand lever from mid or "shut" position compresses the spring, and this initial compression load on the spring is capable of operating the hand lever B1 so as to bring that lever back to mid position when freed, as hereinafter described. Pipes D2, D3 from the ends of the cylinders A1, A2 lead to a valve-box E at the controlling station, which box is connected to the pressure and exhaust mains E1, E2. In this box is an

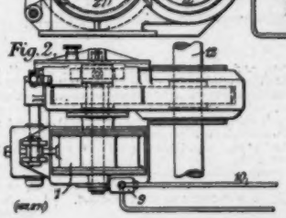


ordinary slide valve E5 controlling the connection of the pipes D2, D3, with these mains. This valve is operated by a hand lever E4. In operation, with the hand lever E4 at the controlling station at mid position as shown, it will be seen that the valve E5 is so placed that the pipes D2, D3 leading from the cylinders A1, A2 to the valve-box E are both open to the exhaust E2 from that box. The fluid pressure in these two cylinders is thus equalised, and the centering spring D1 is then free to move the hand lever B to mid-position, and thereby place the valve C also in "shut" position, so stopping the lift. On the hand lever E4 at the controlling station being thrown to one side or the other, accordingly as it is desired to admit pressure through one or other of the pipes C1, C2 to either the lifting or lowering cylinder of the lift, it so throws the valve E5 that pressure is admitted by either the pipe D2 or D3 to either the cylinder A1 or A2. The double-ended ram A moves accordingly, and through its connection with the main valve hand lever B throws the main valve C to either "lift" or "lower" position. At the same time the movement of the lever B compresses the centering spring D1. Upon the hand lever E4 being brought back to mid position, the valve E5 puts both cylinders A1, A2 in communication with the exhaust E2, and the centering spring D1 returns the main valve C to "shut" position, as hereinbefore described. (*Accepted July 4, 1917.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

107,271. J. Brown, and Scotts' Shipbuilding and Engineering Company, Limited, Greenock, and Compayne, Limited, Westminster. Clutch-Control Gear. (3 *Figs.*) July 14, 1916.—This invention relates to a clutch-control gear for ensuring automatic operation of a clutch when a shaft adapted to be driven from two sources of power attains a predetermined speed of rotation. The specific object of the invention is to provide means whereby, if the two driving sources are both in driving connection with the shaft, one of them will be disconnected or connected automatically when a certain speed of rotation is attained and cannot be again put in or out of driving connection

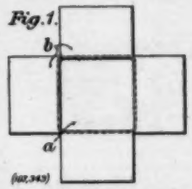


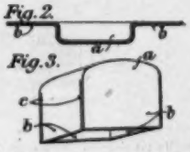


until the automatic control gear is reset. The invention consists broadly of a clutch-control gear comprising a shaft adapted to be driven by two sources of power and automatic means controlled by the rotation of the shaft for automatically operating the clutch when the shaft attains a certain predetermined speed of rotation, and means for rendering reverse operation of the clutch dependent upon the resetting of the automatic control gear. The clutch may be operated by hand at speeds below that at which the automatic operation occurs. 1 is a variable delivery pump, connected by a closed pipe system to a ram cylinder 2, of which the ram 3 is connected to one end of a clutch-operating lever 5. The pipes 7 and 8 from the pump are connected to a flow-regulating valve 9, which functions to ensure that the delivery from the pump 1 always flows to the ram cylinder in the same direction and through the pipe 10 irrespective of the direction in which the pump is rotated. The pump 1 is driven from the driven shaft 12. The delivery of the pump 1 is controlled by the adjustment of an eccentric stroke-controlling ring within the pump, as well understood. In its normal position the stroke-controlling device is maintained in a position which permits only a small discharge from the pump, and the device is locked in this position by the engagement of an arm 23 of a spring-controlled trip lever 23 with an abutment on the rod 20. The trip lever 23 has an arm 25 which co-operates with an eccentric-ring governor 26, consisting of a ring whose centre of gravity is eccentric to the centre of rotation. The ring 26 is connected to, and rotates in company with, the governor shaft 27, which is connected to, and rotates in company with, the driving shaft of the pump. Ring 26 is supported in the position shown by means of a spring. When the speed of revolution of the pump 1 and the governor shaft 27 reaches the maximum for which the apparatus is set, centrifugal force will cause the ring 26 to change its position and operate the spring-controlled trip lever 23 by reason of the engagement cam-fashion of the ring 26 with its arm 25. The tripping of lever 23 will disengage the arm 22 from the rod 20. The spring 21 thereupon forces the rod 20 over, and the stroke-controlling device is thrown over to give the pump its full stroke for maximum discharge. The pressure in the ram cylinder 2 now rises and moves the ram 3 and, as a consequence, the clutch-operating lever 5 is operated to disconnect the clutch. When it is desired to re-engage the clutch, the stroke-controlling lever 15 is operated to reset the stroke-controlling device in its normal small-stroke position. The operation of the apparatus is as follows: Assuming the shaft 12 to be driven by the electrical gearing, the clutch coupling between the shaft 12 and the electrical drive will, of course, be in. Assume now that the main motors, which are also in driving connection with the shaft 12, are started up, then the shaft 12 will be driven by both the electrically-driven gearing and the main motors until the main motors attain a certain predetermined speed, whereupon the trip lever 23 will be operated in the manner before described, and the electrically-driven gearing will be declutched from the shaft 12, which will then be driven only by the main motors, and, moreover, the clutch cannot be let in again to connect up the electrical drive until the control apparatus is reset. (*Accepted July 4, 1917.*)

MINING, METALLURGY AND METAL WORKING.

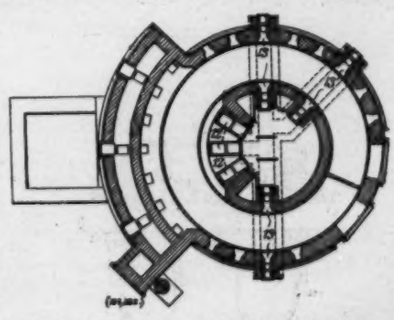
107,343. H. S. Thomas, Cardiff, C. A. Smith, Blakedown, near Kidderminster, and Z. Webb-Onions, Birmingham. Annealing Covers. (6 *Figs.*) December 30, 1916.—The invention comprises improvements in annealing covers, and refers to that class of such cover which is produced from a blank of sheet metal under a press. In carrying the invention





into practice a blank sheet of metal of the form of a simple cross (Fig. 1) is taken, the centre portion of which is cupped under a press so as to produce the upper part *a* of the cover free of all joins. The additional depth of the sides is obtained by folding the four projecting portions *b* of the blank to the form shown in Fig. 3, these folded portions being finally welded along the edges as indicated at *c* in Fig. 3. (*Accepted July 4, 1917.*)

107,332. Stein and Atkinson, Limited, and J. S. Atkinson, Westminster, and Kayser, Ellison and Co., Limited, and C. W. Kayser, Sheffield. Heating Furnaces. (5 *Figs.*) November 18, 1916.—This invention has reference to heating furnaces of the continuous type, having circular revolving hearths or beds. In certain heat treatments it is advantageous to heat up the material charged on to the furnace hearth or bed gradually and to allow the charge to cool down gradually in the furnace before withdrawal; other heat treatments require that the charge be heated up rapidly and cooled down gradually or heated up and cooled down rapidly. The invention provides a construction of furnace of the kind referred to in which it shall

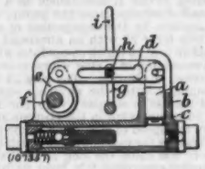


be possible to employ any one of the three heat treatments mentioned. The invention also provides a construction of furnace of the kind referred to in which it shall be possible to change over from one mode of heat treatment to another quickly and easily and without constructional alteration in the furnace. In accordance with this invention, the structure of a furnace of the kind referred to is provided with a plurality of flame-outlet passages 12, 13, divided into primary passages 12 and secondary passages 13, the flame-outlet passages being controlled and functioning in accordance with the heat treatment to be applied to the charge on the furnace hearth or bed. (*Accepted July 4, 1917.*)

MOTOR ROAD VEHICLES.

107,337. J. S. Spittle, Hall Green, Worcester. Lubricant Pumps. (2 *Figs.*) December 2, 1916.—This invention has for its object to construct an improved mechanically-driven variable-throw lubricant pump for use on motor vehicles, the pump being of the type in which a plunger is actuated from a

crank or eccentric through a lever having a variable fulcrum. A plunger *a* reciprocating in a cylinder *b* formed in the body *c* of the mechanism has pivoted to its outer end a lever *d*, which is slotted in a longitudinal direction at or near its centre, and this lever is pivoted to one end of a connecting rod *e*, which is actuated by an eccentric *f* or crank, the connecting rod *e* and the plunger *a* being arranged practically parallel, with the lever *d* between them.



An adjustment lever *g* pivoted on the body passes through a fulcrum piece *h*, which slides in the slot of the lever *d* and in grooves in the body part. At its outer end the adjustment lever is connected to an operating lever *i*, to which is attached a Bowden wire connected to a lever by which its position can be varied for changing the position of the fulcrum piece. The throw of the plunger is varied by operation of the adjusting lever. (*Accepted July 4, 1917.*)

107,314. H. H. Patrick, and the Patrick Engineering Company, Limited, Birmingham. Mechanically-Propelled Cycles. (2 *Figs.*) September 26, 1916.—This invention relates to that type of cycle in which a self-contained motor unit is mounted over the rear road wheel of an ordinary pedal cycle and connected to the said wheel by a belt or chain. A horizontal bracket *a* is attached to the back stays *b* of the cycle. On the bracket are carried an engine *d*, a countershaft *e* and a magneto *f*, the shafts of the engine and magneto being parallel to and on

Fig. 1.

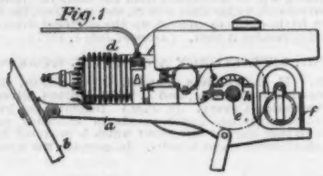
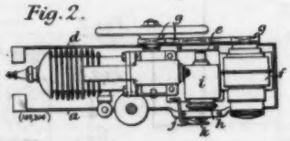


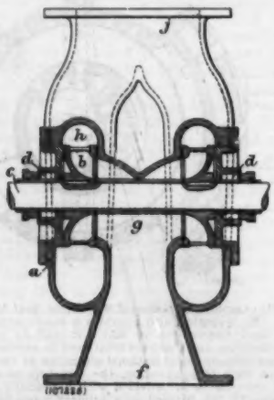
Fig. 2.



opposite sides of the countershaft. All three shafts are connected by gear wheels *g*. The countershaft carries a belt or chain pulley *h* in clutch connection with the shaft. The clutch *i* on the shaft *e* is of the multi-disc type. An internal spring presses the discs together and thereby locks the pulley *h* to the shaft, whilst the lever *j*, pressing on a central spindle *k* in the shaft and acting on the discs, serves to release the pulley. Movement of the lever is effected by a Bowden wire control from a lever on the handle bar of the machine. Motion is transmitted to a pulley on the road wheel by a belt or chain. (*Accepted July 4, 1917.*)

PUMPS.

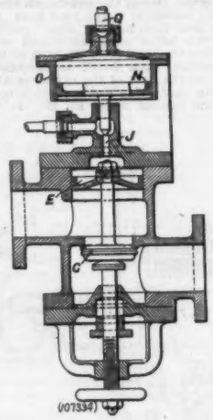
107,226. J. Stone and Co., Limited, Deptford, and W. S. Parsons, Grove Park. Centrifugal Pumps. (3 *Figs.*) June 16, 1916.—This invention relates to centrifugal pumps of the impeller type. This invention provides for obtaining the combined effects of balance of the pump, and delivery pressure on the glands, in pumps of the plain centrifugal type, by arranging impellers of the known centrifugal type so that the reactions in the direction of the axis of the shaft are equal and opposite, whereby the pump, in all circumstances and under all conditions, works in perfect hydraulic balance, and so that delivery of the impellers is on the glands and the suctions are remote from such



glands, whereby the latter are hydraulically sealed by the liquid in the pumps. *a* is the pump casing containing impellers *b* mounted on a shaft *c*, which passes through glands *d*. The suction inlet *f* leads into a suction chamber *g* arranged between the impellers *b* and shaped interiorly so as to direct the water to respective sides and into respective impellers *b*. The delivery chambers *h* of the two impeller casings *a* are suitably joined into one delivery connection *j*. The bearings and glands *d* of the pump are on the outer walls of the impeller casings *a*, and are thus subjected to whatever may be the pressure of the delivery of the pump. In any case they are never subjected to suction. (*Accepted July 4, 1917.*)

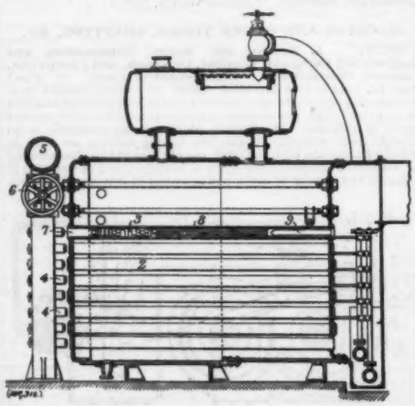
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

107,334. H. E. Yarrow, Scotstoun, Glasgow. Oil-Fired Boilers. (1 *Fig.*) November 24, 1916.—In the working of oil-fired boilers a sudden reduction in the air pressure by the stoppage of the fan, or from other cause, may cause the flames to pass from the furnace to the stokehold. This danger is obviated if the oil supply to the furnaces is automatically closed when the air pressure in the stokehold is reduced by a given amount. For this purpose, according to the invention, one face of a piston N, movable in a cylinder O, or of a flexible diaphragm, is exposed through a pipe Q to the air pressure existing in the stokehold, and the other face to the atmospheric pressure. A given reduction in the air pressure obtaining in the stokehold will displace the piston in the cylinder or flexible diaphragm and



thereby cause a valve controlling the oil-fuel supply to the burners to be immediately closed. The space above a piston E is connected with a narrow passage J closed by the needle valve, connected to the piston N movable in the cylinder O, which is open below but closed above by a cover. The cover is in connection by the tube Q with the compartment under air pressure, and as long as the upper surface of the piston N is exposed to this pressure at its normal value the needle valve allows the piston N to be raised by the oil pressure acting on the needle valve, which is thereby opened, and the pressure being relieved from the upper surface of the piston E, the latter rises and closes the valve C which regulates the supply of oil fuel to the furnace. (*Accepted July 4, 1917.*)

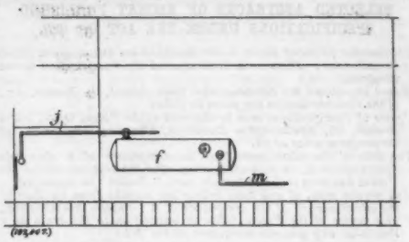
107,316. P. St. G. Kirke, Westminster. Steam Superheaters. (2 *Figs.*) October 4, 1916.—This invention has relation to the production of superheated steam, and has reference in particular, but not exclusively, to the superheating of steam generated by the heat produced by burning a mixture of gaseous fuel and air on the surface of, or in the neighbourhood of, an incandescent body placed within a boiler fire tube. Steam superheating arrangements in accordance with this invention comprise boiler tubes 2, each packed or charged for a portion of their length with packing material 3, in contact with or in the neighbourhood of which combustion of the gaseous fuel may take place, superheating coils 8 arranged within another portion



of each of said tubes, and further packing material 9 in the remainder of said tubes so as to reduce the temperature of the gases and combustion products to a few degrees above that of the saturated steam. 4 are gaseous fuel supply nozzles, there being a nozzle for each tube 2. Gaseous fuel is supplied to the nozzles 4 through a main 5, and is regulated by a valve 6. The gaseous fuel from the nozzles 4 and air are induced into mixing chambers 7, with which the one end of each tube 2 is provided, to form therein a combustible mixture, combustion of which is completed in contact with, or in the neighbourhood of, the refractory material 3, all in manner well understood. (*Accepted July 4, 1917.*)

SHIPS AND NAUTICAL APPLIANCES.

107,247. E. Ringsted, Broomhill, Glasgow, and Barclay, Curle and Co., Limited, Whiteinch, Glasgow. Watertight Doors. (2 *Figs.*) June 24, 1916.—This invention relates to a mode of operating the watertight doors of motor-driven vessels having engines of the Diesel type. Under this invention, compressed air supplied from the compressed-air plant of the Diesel engine is used for operating the watertight doors. In carrying out the invention a compressed-air reservoir *f* is provided and is connected by a pipe *m* with the Diesel engine compressed-air system and is supplied therefrom, the pressure at this reservoir being reduced, as desired, by means of a reducing valve or otherwise. From the reservoir compressed-air mains *j* are conducted to the various doors so as to supply compressed air to operate the mechanism for opening and closing these doors. The various



compressed-air mains are under valve control from the bridge or other part of the ship so that the compressed air could be supplied to the doors, or any one or set of doors, as desired. (*Accepted July 4, 1917.*)

TEXTILE MACHINERY.

107,351. J. Sykes, Barkisland, near Halifax. Stop-Motions of Looms. (2 *Figs.*) January 23, 1917.—This invention consists of improved mechanism which, on breakage or failure of weft, is operated by the weft stop-motion to simultaneously put the picking motion out of action and to stop the loom, also for locking the same out of action, and upon the loom being again started for preventing the picking motion being disengaged until the loom is properly started, or when not required. According to this invention, as applied to a bastard loom with dandy pick, otherwise a dandy loom with moving boxes at one side only, the weft stop bolt B of an ordinary centre weft stop-motion, on the breakage or failure of weft, strikes, during the succeeding beat up, a projection C upon the lever D. This lever is fulcrumed upon the same stud E as a longer lever F connected by rod G and other mechanism, not shown, with the picking clutch on the picking shaft at the box end of the loom, and between the loose ends of these levers, which project through a slot P in the setting-on-plate M, rests an arm H of a lever

Fig. 1.

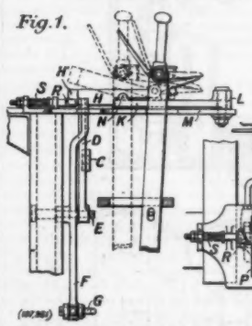
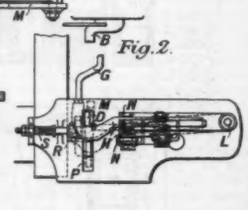


Fig. 2.



fulcrumed on a horizontal lever K pivoting at L upon the said plate. The arm H is capable of movement at right angles to and independent of the lever K, but when in the normal position, as shown in the drawing, it fits between the lugs N on the lever K so that the two levers become integral on a lateral movement, having their fulcrum at L. The movement imparted to lever D by the bolt B is conveyed by arm H to lever F—as shown in dotted lines at Fig. 2—which operates rod G to put the picking clutch out of action. Simultaneously the lever K engages the setting-on rod and releases same to stop the loom in the ordinary way. The arm H has a taper or bevelled nose H1, which engages a correspondingly tapered end of a catch R, and during the aforesaid lateral movement it moves the said catch in opposition to a spring S, until eventually on clearing the same the catch is released and returns to lock or hold the said arm and lever F, and prevent their return until it is required to put the picking clutch into gear or until the loom is properly started. (*Accepted July 4, 1917.*)

Dust in Steel Works.—There are plenty of sources of dust in steel works. The charging, handling and dumping of the materials with the aid of chutes and skips produces ample dust of ores, coke and limestone; the blast-furnaces send graphite and fumes of many kinds into the air; the gas sent to the stoves carries dust; the dolomite sheds, open hearths, rolling mills, soaking pits, soft coal fires, converters, the grinding shop and foundry, all supply dust, which the constant movement of heavy masses helps to keep in suspension. In sampling the dust of steel works the United States Bureau of Mines (Technical Paper 153, compiled by J. A. Watkins, of the Public Health Service) made use of the samplers of A. J. Lanza and E. A. Higgins. The collector carries part of a Draeger oxygen-breathing apparatus, which is combined with a dust filter. The collector inhales through this filter and exhales into the litre bag of Draeger, which in this case resembles a big sausage, as high as the man, of a capacity of 35 litres. The dust filter is charged with granulated sugar, which has rendered excellent service as a dust catcher in South Africa when the dangerous dust of the African mines was being studied. Near ore bins Watkins found as much as 23.5 milligrammes of dust for 100 litres, and this dust was mostly of exceedingly small ultra-microscopic particles, which coughing would not remove. The irritating sharp-cornered coke dust, the predominating dolomite dust, the very fine flue dust, the ganister and roll scale dusts, are also objectionable; the graphite was mostly found in scales or flakes of $\frac{1}{4}$ mm. The remedies recommended, respirators, dust washers, sprinklers and ventilators, are not new; as the dolomite shed dust is partly calcined and caustic, special clothes and washing and bathing facilities should be provided.